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Mathematical Modeling and New Experiments on Durability of Paper: A Progress Report

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National Measurement Laboratory

April 11, 1979

Progress Report Covering the Period
February 1, 1977 - September 30, 1978

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Prepared for

Bureau of Engraving and Printing
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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, ***Secretary***

Jordan J. Baruch, ***Assistant Secretary for Science and Technology***

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

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Disclaimer

The publication of the trade names of equipments used in this project implies neither an endorsement nor a disapproval of these equipments for any purposes as described in this report.

EXECUTIVE SUMMARY

As a necessary step towards the modeling of the microstructural changes of paper due to environmental and mechanical loadings, a computer-aided data file for a collection of 47 NBS reports (1953-1976) is created. Using an in-house experimental database management system (COLLIN) as implemented on an NBS computer (DEC PDP-10), a mini-databank for the 47 technical reports is set up with the following searchable parameters: (a) report number, (b) author's name, (c) keyword, (d) test sample label, and (e) primary test variable. Each search will yield a complete record containing all the searchable information as well as (f) title of report, (g) citation, (h) the abstract, and (i) the so-called secondary test variable. To obtain quantitative information from any specific report for some combinations of sample labels and test variables for which experimental data were reported, a data tape is prepared and implemented for retrieval on a leased mini-computer graphical system (Tektronix 4051 with printer 4641 and plotter 4662). The operating system using the computer language BASIC is general enough to assist any scientist or engineer to create a personal data file at a reasonable cost. It is clearly demonstrated that no prior training in the use of a computer is necessary for the implementation of this project.

During this reporting period, experiments on relating the quantity of water in the cellulose walls of pulp fibers to the cross-sectional morphology of fibers in paper were in progress. A brief discussion of this aspect of work is included in this report.

Keywords:

Computer graphics; data base management; data retrieval; durability; fatigue; interactive system; mathematical modeling; paper; paper fiber; report retrieval; scientific data.

FOREWORD

For more than twenty-five years, the Bureau of Engraving and Printing (U.S. Department of Treasury) and the National Bureau of Standards (U.S. Department of Commerce) collaborated in a unique research program on the improvement of the durability of the U.S. currency and stamp papers. A total of about fifty technical reports, some containing sensitive information, was generated at NBS for dissemination on a need-to-know basis.

In the spring of 1975, Dr. E. L. Graminski, the project leader of that NBS paper physics program and a co-author of this report, requested my assistance in formulating a conceptual and quantitative predictive model on the degradation mechanisms of currency paper. The conceptual model was subsequently formulated in an NBS internal report (NBSIR 76-1062) published in April 1976. An abbreviated version of that report appeared in a Tappi journal (Tappi, 60 (1977), pp. 156-159) in January 1977.

The second phase of Dr. Graminski's request remains to be completed. A quantitative predictive model, sometimes known as a mathematical model, cannot be formulated without the availability of a minimal quantity of well-documented data. In the case of the U.S. currency and stamp papers, we are fortunate that most of the data available have been generated at NBS. However, two questions on the nature of the available data need to be answered first:

Question 1 Are the available data well-documented for a systematic study of the macroscopic and microscopic phenomena of the fatigue of currency paper?

Question 2 Are the available data appropriate for guiding and validating the formulation of a predictive model?

Unfortunately, both Dr. Graminski and I came to the conclusion that the answers to both questions are in the negative. It is not the purpose of this report to go into the details as to why we reached that conclusion, but we did arrive at a second conclusion which led to the initiation of this project, namely, the collection of NBS Paper Physics Reports can be used to fill partially a mini-databank for completion at some future date. A collaborative project between Dr. Graminski's group and mine was thus initiated in February 1977 with the specific goal of using a mini-computer system to manage and prepare the NBS Paper Physics Data File for mathematical modeling.

The use of a computer system to manage and retrieve scientific data has been known since the early 1950's when the second-generation computers became available. As a matter of fact, NBS has been a leader in this field through its numerous centers of critically evaluated data and the 15-year-old Office of Standard Reference Data. Our primary goal in this project is, therefore, not to show that a database for paper physics can be established on a reasonably efficient computer system, but rather to demonstrate that any scientist not necessarily proficient in computer usage can create a computer-aided data file for his or her personal use at a reasonable cost. If our work is favorably received, we may also achieve a secondary goal, i.e., to show the technical community the benefit of having a rapid and reliable means of data communication among scientists who choose to report their findings on computer tapes, disks, or other data-storage devices.

To emphasize the point that a prior knowledge of computer usage is not a prerequisite, I recruited a high school student (Ivan Fong, the second author), and a laboratory technician (Elizabeth Toth, the third author) to implement the file design on two computer systems. The computer software and the subsequent completion of the data file reported here are largely the work of these two authors. In addition we are most grateful to Mr. Joseph Collica, the developer of the software COLLIN, and Mrs. Elizabeth Fong, my wife and a computer scientist, both with the NBS Institute for Computer Sciences and Technology, for their expert assistance in the successful completion of this project.

During this reporting period, Dr. E. L. Graminski and his co-workers also carried out some experimental work on predicting the durability of paper from morphological information on the paper fibers. A brief discussion of this experimental work which is still in progress is included in this report under Section 10 entitled "Other Work in Progress."

Jeffrey T. Fong

February 1979.

Mathematical Modeling and New Experiments on Durability of Paper: A Progress Report

J. T. Fong, I. K. Fong, E. E. Toth, and E. L. Graminski

1. Scientific Data and Mathematical Modeling

The work reported herein is a continuation of a study on the durability of paper that was last reported in 1976 [1][1]. It was shown in that report[2] that the degradation of a large class of paper might be conceptually attributed to the change in the strength and morphology of microscopic elements such as fibers and fiber-fiber connections when paper specimens were subjected to repetitive loadings under a variety of environmental conditions. It was proposed that a self-consistent microscopic degradation model of paper be used to explain the loss of modulus due to repetitive flexing if the appropriate data on the microscopic and the macroscopic scales of observations were available to guide the development of such a model.

Unfortunately, progress on both the strength and the morphology aspects of this special topic of research lagged far behind what was anticipated in 1976. For example, Graminski and Kirsch [3,4,5] reported some progress in measuring the morphology of paper through some semi-automatic fiber-tracing and automatic scanning algorithms. Much, however, remains to be done to develop the technique to the point

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[1] Figure in brackets denotes a reference listed at the end of this report.

[2] A shorter version of the report has since appeared in a Tappi journal. See [2].

where statistically meaningful information could be used to assist the modeling effort. There was even less progress in the area of single-fiber strength characterization, and it is not at all surprising that the totality of scientific data available to push the modeling effort beyond the initial conceptual stage [1] is still insufficient today as it was in 1976.

Since paper usage is widespread and paper-making is energy-intensive, research on the durability of paper is expected to continue in spite of the current lack of advances in both experimental and theoretical work. At a recent symposium on fatigue mechanisms of metals, polymers, and composites, Fong [6] introduced three microscopic levels (10^{-10} to 10^{-8}m; 10^{-8} to 10^{-6}m; 10^{-6} to 10^{-4}m) and the concept of "nested modeling" to launch a systematic approach to fatigue mechanism research. This implies that there exists a need not only of data generation as traditionally understood by all material scientists and engineers, but also of data management to handle the large volume of the microscopic information so generated. Since the microstructure of paper is relatively simple (characteristic lengths varying between 10^{-6} and 10^{-4}m), it appeared that the problem of implementing a computer-assisted data file for modeling the mechanical behavior of paper is not only feasible, but also most desirable as the logical step prior to a full-scale modeling effort.

The purpose of this report is to document an attempt to solve the data management aspect of the technical problem, i.e., to improve the durability of paper. Based on a collection of 47 technical reports issued by the National Bureau of Standards (NBS) to the Bureau of

Engraving and Printing (BEP) during a twenty-three year period, a computer-assisted data file, known as the NBS Paper Physics Data File, is created for retrieval on a mini-computer (Tektronix 4051) in collaboration with a medium-size computer (DEC-10) both located at NBS. Following a complete description of the file design and some sample output, a simple-minded cost-benefit analysis is presented to indicate the usefulness of this small-scale management system for scientific data.[3]

2. Computer as an Intelligent File Manager

The use of a computer to perform either numerical computation or non-numeric information storage and retrieval has been known for a long time. In the early years of computing, the computation-oriented and the information-oriented users considered the computer as two separate tools, namely, it is either a super-calculator or a giant file system. In the case of a super-calculator, the user manipulates the data according to precise mathematical rules and stores the numerical information either on disks or tapes for future uses. In the case of a giant file system, the user takes advantage of the memory devices such as disks and magnetic tapes for storage of textual information in the form of retrievable records. In both cases, the speed and the memory-size of a computer are crucial in enhancing the power of this labor-saving device.

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[3] During this reporting period, experiments on relating the quantity of water in the cellulose walls of pulp fibers to the cross-sectional morphology of fibers in paper were in progress. Since there is no significant result worthy of reporting, we choose to include in this report under Section 10 a brief discussion of this aspect of work even though the data management aspect and the experimental aspect of the same technical problem are at this stage largely unconnected.

Beginning in the late fifties[4], the information-oriented users succeeded in developing "generalized" routines capable of sorting any file regardless of its data content. Clearly, the price of generalized processing is a reduction in operating efficiency, but as computer technology continued to evolve with decreasing price/performance ratios, the issue of cost tradeoff for adopting or rejecting the so-called data base management system became largely academic during the last two decades. Computerized data banks using sophisticated data base management systems are today commonplace in business, industry, government, and research organizations.[5] A different type of question has evolved: Is the computer intelligent enough to be "discreet" about a certain type of sensitive information and "frugal" about the retention of essential information by discarding "non-essential" data?

The answer is, of course, no, or, at least, not yet. The fundamental reason lies in the nature of a computer which decomposes any issue or task into a <u>finite</u> number of sub-elements, and for every finite decomposition rule prescribed by a human being it is usually possible to find a problem in real life that defies a neat classfication. This is particularly true in an information-loaded activity where the nature of the information is such that it not only changes rapidly but also is coupled with the way new information is generated. The mathematical modeling of the degradation of paper to improve its durability is such an activity because it needs preliminary test data and generates new predictions which lead to new experimental programs and a totally new set of test information. The challenge before us is

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[4] See, e.g., McGee [7].

[5] See, e.g., Fry and Sibley [8], Fong et al [9], Wetzler [10], and Darrow and Belilove [11].

to endow the data base management system with as much analytic capability as we can think of within a reasonable and appropriate financial framework. During the last few years, we have seen many attempts to meet this challenge, and depending on the nature of the problem in hand, the solutions will differ from computer to computer and from problem to problem.[6] But the overall objectives of these attempts are the same, i.e., how to make the computer "intelligent" enough to assist the human user in storing, retrieving, critically evaluating, updating, analyzing, and to some extent sharing with fellow-users, a compatible body of information.

The main result of this report is to show that for a reasonable cost, both in dollars and in time, a scientist can create a data file with the aid of a small-size computing system to meet almost all of his/her data needs including the need to analyze, interpret, and share with others both raw and processed information. It is assumed in this report that the scientist is mathematically literate, but has had no background in working with a computer as a systems programmer.

3. Design of a Scientific Data Filing System

A data filing system differs from a data bank in the sense that the former need not cover all the possible data items in any specialized field whereas the latter does. A data filing system is, therefore, a more personalized system, and needs only a small-size computer to house the operating system. On the other hand, a data filing system should have as much computing power as a scientist can muster with all

[6] See, e.g., Ruff et al [12], Vander Molen and Gerstenberg [13], Wagman et al [14], and Mendelssohn [15].

the desirable output features such as plotting and printing. This means the small-size computer selected for this purpose should possess two features: (a) it can compute, and (b) it can act as a terminal with access to larger computers via telephone links. Because the data filing system is designed to be personalized, the small-size computer should have a screen to permit instant user/computer interaction.

In July 1977, a computer-assisted graphical system with the appropriate output devices and data communication interface components was leased from a computer manufacturer on a quarterly basis to implement this design. The configuration of the system is given schematically in Fig. 1.

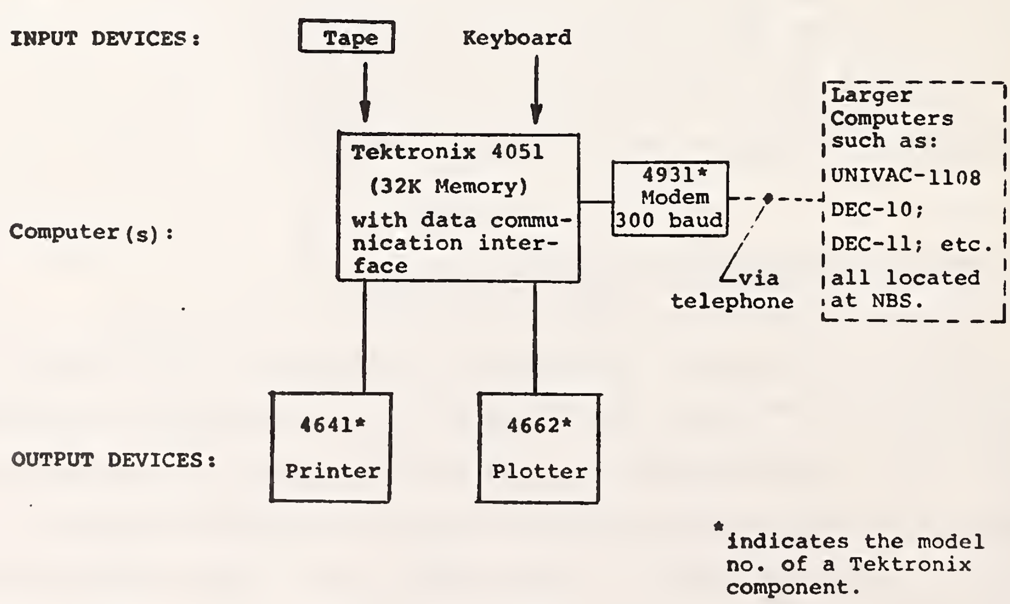

Fig. 1 The configuration of a scientific data filing system.

For a given collection of technical reports, we design a scientific data filing system with the following two distinct retrieval features:

(a) Report Retrieval

Most work done in this field relies on retrieval by author or keywords. For a scientific data filing system, it would be most desirable to go one step further, i.e. to retrieve one or more reports via sample labels and test variables. This allows the scientist to correlate information from several reports on the same sample and test variable.

(b) Data Retrieval

Data desired by the scientist should be retrieved not only in tabular forms on the printer, but also on report-quality drawings from the plotter for visual examination. Furthermore, it is desirable to couple the data storage device with the computer such that further mathematical analysis can be made on the data to generate new plots.

Both features are needed by the scientist to critically evaluate the data as a prerequisite for mathematical modeling.

4. NBS Paper Physics Data File - An Example of System Implementation

With the arrival of the leased Tektronix system in July 1977, we began the actual work of implementing the filing system design by creating an NBS Paper Physics Data File consisting of 47 reports to the Bureau of Engraving and Printing over a span of 23 years[7].

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[7] See Appendix I for a complete listing of the 47 reports.

To prove that the task of implementation can be done by a scientist without a background in systems programming, the second and third authors (I. Fong, and E. Toth) were recruited to join the project team with I. Fong handling the data retrieval and E. Toth the report retrieval features of the filing system. We further enlisted the assistance of two computer specialists (J. Collica and E. Fong) at the NBS Institute for Computer Sciences and Technology to activate an experimental data base management system known as COLLIN.[8] The following assignment of responsibility was made:

Task	Designer	Supervisor
(a) Report Retrieval	E. Toth	E. Graminski
(b) Data Retrieval	I. Fong	J. Fong

I. Fong was also asked to furnish a list of sample labels and test variables to E. Toth for implementing the report retrieval feature of the filing system. The computer hardware and software for handling the two tasks are as follows:

Task	Hardware	Software
(a) Report Retrieval	Tektronix 4051 Tektronix 4641 Tektronix 4931 Telephone DEC-10	COLLIN[8]
(b) Data Retrieval	Tektronix 4051 Tektronix tapes Tektronix 4641 Tektronix 4662	BASIC[9] and NBS Paper Physics Data Operating System (Appendix VI)

[8] For a complete description of COLLIN, see Appendix IV.

[9] For a complete description of the Graphic System BASIC language as implemented on the Tektronix 4051, see reference [16].

To assist us in estimating the effort spent by I. Fong and E. Toth in implementing the filing system, the following schedule was set up and carried out by both of them during 1977 and 1978:

Name	Subtasks in 1977	Subtasks in 1978	Total[10]
E. Toth (half-time)	Step 1 (Feb - July) Conversion of Reports into a database.		3 p.m.
	Step 2 (Aug - Sept) Search for Source Tape from database.		1 p.m.
I. Fong (full-time)	Step 3 (July - Aug) Conversion of Report into Data Tape.		2 p.m.
		Step 4 (July -Aug) Retrieval of Data from Source Tape.	2 p.m.

Details of each of the four steps outlined in the above table are given in the next four sections.

5. Step 1. Conversion of Reports into a Database

To convert a collection of technical reports into a database, it is necessary to characterize the content of each report by a finite set of descriptors and tables of test data. In addition to the usual descriptors such as report number, title, author(s), abstract, and keywords, three new set of descriptors are introduced:

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[10] The total effort by each person is given in person-months or p.m. as indicated.

(a) Sample Labels, to be denoted by S1, S2,.....

(b) Primary Test Variables, to be denoted by P1, P2,....

(c) Secondary Test Variables, to be denoted by A, B, etc.

For all practical purposes, all test data can be represented in the form of either a single measurement for one or more sample labels, or a series of measurements of the so-called primary test variable as a funtion of the secondary test variable for some given sample label. This allows the scientist to locate data point(s) of a similar test for a class of sample descriptors in several reports for work conducted over a good number of years. To implement this idea, we set up three files in the experimental computer facility at NBS:

File Name	Calling Code	Searchable Field	Non-Searchable Field
NBSPPF	COLL2	NBS Number Author Keywords	Title Citation
PPFABS	COLL3	NBS Number	Abstract
PPFVAR	COLL6	NBS Number Sample Label Primary Test Var.	Secondary Test Var.

Following the instructions given in Appendix IV on the use of the database management system COLLIN, the descriptors for all 47 reports for files NBSPPF and PPFABS, and those for three reports (NBS Number 4509, 4664, and 4804) for file PPFVAR were entered into the computer DEC-10 through the Tektronix 4051 in its terminal mode.[11] As a check of the correctness of the file content, each calling code

[11] A Texas Instrument Silent 700 was also used as a terminal for this project.

upon execution will reveal its data definition to remind the user what are and what are not searchable. For instance, the calling code COLL2 yields the following data definition for three searchable fields and two non-searchable fields:

```
.EXECUTE COLL2
LINK:   LOADING
[LNKXCT COLLIN EXECUTION]
WELCOME TO THE COLLIN DATA BASE SYSTEM
YOU ARE ACCESSING DATA BASE NBSPPF
NUMBER OF RECORDS IN DATA BASE IS  47
MAX POSSIBLE RECORDS ARE 990
DB POINTER IS   47

DATA DEFINITION FOLLOWS
NUMBER OF DATA FIELDS DEFINED 5
SPACE TAKEN BY DATA DEF STORAGE 78
NAME NBS NUMBER
          ALPHANUMERIC,   12 CHARACTERS,   1 OCCURRENCES, SEARCH
NAME AUTHOR
          ALPHANUMERIC,   20 CHARACTERS,   4 OCCURRENCES, SEARCH
NAME TITLE
          ALPHANUMERIC,   80 CHARACTERS,   2 OCCURRENCES, NON SEARCH
NAME CITATION
          ALPHANUMERIC,   80 CHARACTERS,   2 OCCURRENCES, NON SEARCH
NAME KEYWORDS
          ALPHANUMERIC,   20 CHARACTERS,   9 OCCURRENCES, SEARCH
```

Due to lack of I. Fong's time to complete the project, the file PPFVAR is currently complete only for three reports with the remaining 44 reports awaiting further implementation.

6. Step 2. Search for Source Tape from Database

A user's manual for accessing the NBS Paper Physics Data File through a terminal has been included in this report as Appendix II. The aim of each search via any searchable fields[12] (such as keywords, sample labels, primary test variables, etc.) is to examine the output record to see if it is indeed worthwhile to examine a specific report for data retrieval. This step is entitled "search for source tape" because we anticipate having each report converted into a tape

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[12]For lists of words for searchable fields, see Appendix III.

for retrieval and analysis. The following are sample outputs from each of the three files established on the NBS computer DEC-10:

(a) A Typical Record in File NBSPPF under COLL2:

```
**RECORD 000000001
*NBS NUMBER
    NBS 3191
*AUTHOR
    HOBBS
    WORTHINGTON
*TITLE
    CRUMPLING ENDURANCE OF EUROPEAN CURRENCY PAPERS
*CITATION
    NBS PROJECT 0703-20-3830 MARCH 31,1954
*KEYWORDS
    CURRENCY PAPERS
    PRE/TEST
    CRUMPLING NUMBER
    AIR PERMEABILITY
```

(b) A Typical Record in File PPFABS under COLL3:

```
**RECORD 000000033
*NBS NUMBER
    NBS 9659
*ABSTRACT-PART 1
    SEVERAL POLYURETHANE LATICES WERE EVALUATED AS POSSIBLE SIZING MATERIALS
    FOR CURRENCY PAPER.ONLY ONE OF THE LATICES WAS LESS FLEXIBLE THAN
    ANIMAL GLUE INDICATING THAT POLYURETHANES MAY BE BETTER SIZING MATERIALS
    THAN ANIMAL GLUE.EXTRACTION OF REDEEMED CURRENCY WITH METHANOL
    INDICATES THAT THE ACCRETION OF POLAR MATERIALS DOES NOT CONTRIBUTE
    SIGNIFICANTLY TO THE DETERIORATION OF CANTILEVER STIFFNESS.THE DURABILI
    AND PRINTABILITY OF REGULAR DRY-PRINT CURRENCY PAPER IS IMPROVED AS A
    RESULT OF INCREASING THE GLYCERIN CONCENTRATION IN THE SIZE BATH.
```

(c) A Typical Record in File PPFVAR under COLL6:

```
**RECORD 000000003
*NBS NUMBER
    NBS 4509
*S-GROUP 1
    1970GS
    1970M-CONTROL
    1970M-S-1(0.3%SI)
    1970M-S-3(0.7%SI)
    1970M-S-5(0.5%SI)
    1970M-S-17(3.6%SI)
    1970M-S-30(4.1%SI)
    1970M-SI-TYPE 104
    1970M-SI-TYPE 165
*S-GROUP 2
    1970M-CONTROL
    1970M-SI-TYPE 104
    1970M-SI-TYPE 165
    4838-CONTROL
    4838-RESIZED
    4839-RESIZED-SLACK R
    4995A-MELAMINE-GLYCE
    5000-MEL-GLYCE-GLUE
    5001A-MELAMINE
*P-GROUP 1
    ABRASION-WEIGHT LOSS
    BASIS WEIGHT
    BRIGHTNESS
    CRUMPL-AIR PERMEABLT
    ELONGATION-%-CROSS
    ELONGATION-%-MACHINE
    FOLD ENDUR-CROSS
    FOLD ENDUR-MACHINE
    OIL(*10) PENETRATION
*P-GROUP 2
    OPACITY
    SMOOTHNESS
    TEAR STR-CROSS
    TEAR STR-MACHINE
    TENS STR-DRY-CROSS
    TENS STR-DRY-MACHINE
    TENS STR-WET-CROSS
    TENS STR-WET-MACHINE
    THICKNESS
*P-GROUP 3
    WATER PENETRATION
    WATER RESISTANCE
*SECONDARY TEST VARIABLES
    CRUMPLING
    SILICONE COATING-X
```

7. Step 3. Conversion of Report into Data Tape

To convert a report into a data tape, it is necessary to store all descriptors and tables of test data systematically using an operating system developed specifically for this project. This operating system is interactive in nature and a full listing of its program in BASIC is given in Appendix VI. Each data tape is subdivided into nine segments with each segment containing a specific type of information as follows:

Segment File No.	Length of File	Information Content
1	2560 bytes	Report Number Title Author(s) Keywords
2	2560 bytes	Report Number Primary Test Variables
3	2560 bytes	Report Number Sample Labels Secondary Test Variables
4	7680 bytes	Alphanumeric Codes for Data Combinations
5	7680 bytes	Numeric Codes for Data Combinations
6	2560 bytes	Units of Test Data
7	7680 bytes	Primary Test Var. Data vs. Sample Labels.
8	7680 bytes	Primary Test Var. Data for all sample labels with dependence on secondary test var.
9	open (last file)	Secondary Test Var. Data for sample labels listed in Segment File 8.

Upon activating the NBS Paper Physics Data Operating System (OS) simply by pressing the AUTO-LOAD key after inserting OS tape into the Tektronix 4051, the screen will display the following information to request user's action:

```
NBS PAPER PHYSICS DATA FILE  -  JEFFREY FONG AND IVAN FONG, JULY 1978

        KEY  1    INPUT Info Type I (Title, Authors, Keywords)
                  OUTPUT Info Type I

        KEY  2    INPUT Info Type II (Primary Test Variables)
                  OUTPUT Info Type II

        KEY  3    INPUT Info Type III (Sample Labels, Secondary)
                  OUTPUT Info Type III

        KEY  4    OUTPUT Info Types I,II,III, in Matrix Format

        KEY  5    INPUT Info Type IV (Data Combination Codes)
        KEY  6    OUTPUT Info Type IV in Matrix Format

        KEY  7    INPUT Info Type V (Test Data)
        KEY  8    OUTPUT Info Type V in Table Format

        KEY  9    PLOT Primary Test Variable vs. Sample Labels
        KEY 10    PLOT Primary vs. Secondary Test Variables

              ====================================
Press User Definable KEY on upper left of Keyboard to activate FUNCTION.
```

After each report is reduced to a set of tables of test data, the pressing of special keys 1, 2, 3, 5, and 7 enables the user to convert the report into a data tape without any difficulty.[13] The operating system is written in a conversational mode such that the user need not have any knowledge of the intricacies of system programming in order to create a data tape. Once again, because of the lack of time in converting all the reports into tables of numbers, only three reports (NBS 4509, NBS 4664, and NBS 4804) have been stored onto magnetic tapes for retrieval and analysis.

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[13] The pressing of Key 4 is an important intermediate step because it yields a blank matrix such as the one shown on page A.19 of Appendix V to guide the appropriate input of data combination codes and test data.

8. Step 4. Retrieval of Data from Source Tape

Let us assume that a search of the Paper Physics Data File indicates that NBS Report 4509 should be examined for further data retrieval. At this point, we should activate the Paper Physics Data Operating System and the Source Tape for Report 4509 by first pressing the AUTO-LOAD key and then Key 6 to obtain a data matrix as shown on pages A.22 and A.23 of Appendix V. The representation on these two pages indicates what data are and what are not available. The pressing of Key 8 and an appropriate input of data combination codes will give tables of data as illustrated on pages A.24 and A.25 of Appendix V. The use of Keys 9 and 10 will allow the user to obtain report-quality drawings of test data as shown on pages A.26 and A.27 of Appendix V.

Because all test data are stored on a source tape in binary form, they can be retrieved for further mathematical analysis and graphical representation. For the moment, it suffices to say that the feasibility of creating an "intelligent" filing system for a specialized body of scientific data has been demonstrated.

9. A Simple-Minded Cost-Benefit Analysis

It is reasonable to ask at this point whether the benefit of a computer-aided data filing system exceeds the cost of developing and maintaining such a system. This question cannot be answered in a precise form because it is difficult to estimate the long-term benefit of any scientific work. Nevertheless, we believe that our judgment

and managerial experience are sufficient to present here a simple-minded analysis based on a number of ad-hoc assumpticns. In the first place, let us assume that the benefit of any scientific work is at least as large as the total cost of producing that work.[14] This means that the information contained in the 47 reports at approximately $100K per report, at today's prices, may be worth about $5 million. The cost of developing the "intelligent" filing system may be broken down into three categories as follows:

Category of Cost	Cost Estimate	Remarks
Development:		
Computer System:	$16K	Leasing cost for one year.
Programming:	$16K[15]	4.0 p.m. @ $4K per p.m. including overhead.
Planning & Supervision:	$16K	2.0 p.m. @ $8K per p.m. including overhead.
	....	
	$48K	(total for development)
Upkeep/Maintenance:		
Computer System:	$10K	
Programming:	$10K	
Supervision:	$10K	
	....	
	$30K	(total for upkeep)

[14] This assumption is, of course, not necessarilv valid in view of isolated cases of poor management and qualitv of scientific research programs. Nevertheless, on a statistical basis and largely on an act of faith, the society supports research on the premise that the benefit to society will be at least as large as the investment.

[15] This estimate excludes the compensation due I. Fong who joined this project team as a volunteer worker during the summers of 1977 and 1978. An extra $8K would have to be added to the estimate if I. Fong were compensated for his 4 months of effort.

If the development cost is spread over the next five years, the net cost of the "intelligent" filing system will be approximately $40K per year for each of the next five years. If we further assume that the $5 million-information package can be most efficiently extracted in five years to guide in the development of a mathematical model to improve durability of paper, then the cost-to-benefit[16] ratio may be crudely estimated as $200K to $5 million or a ratio of 1 to 25.

Alternatively, if the "intelligent" filing system is not used or even developed, then it is conceivable that the information contained in the 47 reports will largely lie untouched and unused. The loss to the society would have been close to $5 million[17]. We have therefore demonstrated the economic justification of the development of this filing system as a pre-modeling phase of work.

10. Other Work in Progress

The results from a previous investigation indicated that appreciable differences in the cross-sectional morphology of fibers exists between wood and rag pulps [17]. It is possible that these morphological differences can account for the superior durability of rag papers. It is generally believed that the eventual cross-sectional morphology of fibers in paper is controlled by the wet fiber flexibility during the formative stages of papermaking. In

---

[16] This estimate ignores the extra cost of completing the data-to-tape conversion work for the remaining 44 reports. The conversion aspect of the work should now become relatively simple and routine. Hence we are justified in not factoring the extra cost in this estimate.

[17] None of the 47 reports in this collection has been available to the public through the usual channels such as the Superintendent of Documents, U.S. Government Printing Office, or the National Technical Information Service (NTIS), Springfield, Virginia. Even though the information generated at NBS and reported in that collection has been of value to the sponsoring agency, the restricted nature of the 47 reports implies a potential loss of information to the public at large such that the negative benefit is at least as high as the cost of generating the information.

general the wet fiber flexibility increases as the quantity of water in the cellulose walls of pulp fibers increases. Therefore, it is essential to know the relative quantities of water in swollen rag and wood pulp fibers.

The total amount of water, contained in the cell walls together with the water bound to cellulose is known as the fiber saturation point (FSP). The FSP of fibers is usually measured by the solute exclusion principle [18]. A method for measuring FSP was developed and several determinations were made on wood pulps and on cotton fibers. The work on this part of the investigation is still in progress.

The interaction of water with cellulose occurs primarily in the amorphous regions. It would be valuable to know whether the amount of amorphous material increases during the mechanical treatment of pulps resulting in greater accommodation of water or whether the greater accommodation of water results from morphological changes in the amorphous regions. If the amount of amorphous materials increases then more cellulose becomes accessible to water and the quantity of bound water will increase. If the accommodation of more water is through morphological changes in the accessible regions then the amount of bound water will remain constant.

Bound water in the presence of excess water, can be determined calorimetrically by the non-freezing water technique [19, 20, 21]. A method for determining bound water by the non-freezing water technique was developed for pulp fibers in the presence of excess water by differential scanning calorimetry (DSC). The method appears to be satisfactory as the dispersion between duplicate determinations is quite low. A number of determinations of bound water in wood pulps and cotton fibers have been made but the work is incomplete.

Due to the incompleteness of this phase of work, it was decided to postpone reporting the data at this time. The work in progress will be completed and additional work on fractionated currency stock is being contemplated. This work will then be reported on in the next annual report.

11. Concluding Remarks

The creation of a 47-report Paper Physics Data File and the implementation of a 3-tape Data Retrieval System clearly demonstrated the usefulness of an "intelligent" filing system to assist a scientist in meeting his/her data needs. The stage is now set to complete the data conversion phase for the remaining 44 reports and to introduce mathematical analysis routines to usher in the next phase of work, i.e., mathematical modeling. Concurrent with the development of this work was an attempt by Hilsenrath and Breen [22] to introduce an interactive system for data retrieval, statistical and graphical analysis, and data-base management. It would be interesting and useful to compare the two systems, i.e., the one reported in this document versus the one described in [22], to see if certain features overlap and certain others complement. Undoubtedly, the time has come for scientists to consider the reporting of their data and the associated interpretations in some standardized format for either tape or disk storage and retrieval. Such an activity would hasten the day when results of one scientist could be interpreted by another at perhaps thousands of kilometers away in a matter of hours when computers and telephone network become the standard modes of data communication.

12. References

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Appendix I

NBS Paper Physics Data File - List of Reports

No.	Report No.	Report Title	Author(s)	Date
1	NBS 3191	Crumpling endurance of European currency paper.	R. B. Hobbs, and V. Worthington.	Mar. 31, 1954.
2	NBS 4367	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Oct. 14, 1955.
3	NBS 4509	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Jan. 27, 1956.
4	NBS 4664	Improvement of currency and stamp papers.	E. B. Randall, Jr.	May 4, 1956.
5	NBS 4804	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Aug. 1, 1956.
6	NBS 4964	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Dec. 17, 1956.
7	NBS 5104	Laboratory evaluation of experimental currency paper and dry-printed dollar notes from Lot #174.	R. B. Hobbs**	Jan. 11, 1957.
8	NBS 5202	Investigation of the adhesiveness of the glue layer of postage stamps	R. B. Hobbs**	Mar. 28, 1957.
9	NBS 5778	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Feb. 12, 1958.
10	NBS 6334	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Mar. 10, 1959.
11	NBS 6540	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Sep. 18, 1959.
12	NBS 6672	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Feb. 29, 1960.
13	NBS 6932	Improvement of currency and stamp papers.	E. B. Randall, Jr.	Aug. 15, 1960.
14	NBS 6933	Statistical comparison of wear characteristics of old and new dollar notes.	E. B. Randall, Jr., and J. Mandel	Aug. 15, 1960.
15	NBS 7089	Improvement of currency and stamp papers.	W. K. Wilson, and B. W. Forshee	Feb. 15, 1961.
16	NBS 7127	Special technical report: A new type of folding endurance tester.	V. Worthington	Apr. 20, 1961.
17	NBS 7198	Evaluation of currency and stamp papers.	W. K. Wilson, and B. W. Forshee	Jun. 15, 1961.
18	NBS 7416	Evaluation of currency and stamp papers.	W. K. Wilson, and B. W. Forshee.	Jan. 31, 1962.
*19	Special 1	Suggestions for the improvement of U.S. currency.	W. K. Wilson, B. W. Forshee, and L. T. Milliken	May 24, 1962.
20	NBS 7561	Evaluation of currency and stamp papers.	W. K. Wilson, and B. W. Forshee.	July 16, 1962.

* unnumbered report.

** author of report unknown. For retrieval under author's name, the term "SPECIAL REPORT" is used. The name R. B. Hobbs appears inside the report as the responsible official on report preparation.

Appendix I - continued

No.	Report No.	Report Title	Author(s)	Date
21	NBS 7859	Evaluation of currency and stamp papers.	W. K. Wilson, and B. W. Forshee.	Mar. 1, 1963.
22	NBS 8096	Evaluation of currency and stamp papers.	W. K. Wilson, B. W. Forshee, and T. J. Carter.	Oct. 1, 1963.
23	NBS 8316	Evaluation of currency and stamp papers.	W. K. Wilson, B. W. Forshee, and T. J. Carter.	Mar. 16, 1964.
24	NBS 8514	Evaluation of currency and stamp papers.	E. L. Graminski, B. W. Forshee, and T. J. Carter.	July 27, 1964.
25	NBS 8637	Evaluation of currency and stamp papers.	E. L. Graminski, B. W. Forshee, and T. J. Carter.	Feb. 15, 1965.
26	NBS 8638	Determination of glycerol in currency paper.	E. L. Graminski, and B. W. Forshee	Feb. 15, 1965.
27	NBS 8937	Evaluation of currency and stamp papers.	E. L. Graminski, B. W. Forshee, and T. J. Carter.	July 28, 1965.
28	NBS 9035	Evaluation of currency and stamp papers.	E. L. Graminski, B. W. Forshee, and T. J. Carter.	Jan. 31, 1966.
*29	Special 2	Special report: Evaluation of Gilbert currency paper.	E. L. Graminski, B. W. Forshee, and M. W. Bottomley	May 15, 1966.
30	NBS 9510	Evaluation of currency and stamp papers.	E. L. Graminski, and B. W. Forshee.	Mar. 31, 1967.
31	NBS 9597	Evaluation of currency and stamp papers.	E. L. Graminski, and B. W. Forshee.	July 31, 1967.
32	NBS 9681	Evaluation of currency and stamp papers.	E. L. Graminski, and B. W. Forshee.	Jan. 31, 1968.
33	NBS 9859	Evaluation of currency and stamp papers.	E. L. Graminski, B. W. Forshee, and E. E. Toth.	June 28, 1968.
34	NBS 10090	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Jan. 31, 1969.
35	NBS 10229	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Apr. 29, 1970.
36	NBS 10336	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Sep. 17, 1970.
37	NBS 10564	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Apr. 1, 1971.
38	NBS 10465	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Aug. 19, 1971.
39	NBS 10802	Evaluation of currency and stamp papers.	E. L. Graminski, E. E. Toth, and M. A. Smith.	Feb. 15, 1972.
40	NBS 10912	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Oct. 2, 1972.

*unnumbered report.

Appendix I - continued

No.	Report No.	Report Title	Author(s)	Date
41	NBSIR 73-124	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Jan. 30, 1973.
42	NBSIR 73-274	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Aug. 15, 1973.
43	NBSIR 74-431	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Jan. 2, 1974.
44	NBSIR 74-571	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Sep. 6, 1974.
45	NBSIR 75-670	Evaluation of currency and stamp papers.	E. L. Graminski, and E. E. Toth.	Feb. 20, 1975.
46	NBSIR 75-978	Durability of paper.	E. L. Graminski, and E. E. Toth.	Dec. 15, 1975.
47	NBSIR 76-1062	A micro-degradation model for paper.	J. T. Fong, R. G. Rehm, and E. L. Graminski.	Apr. 15, 1976.

Appendix II

A User's Manual for Accessing the NBS Paper Physics Data File

Sample Equipment: Texas Instrument Silent 700

Step	User Action	Remarks
1	Plug in Terminal near a telephone.	
2	Set Speed at 30, Duplex Full, Parity Even, Interface Int, and Line Feed Single/Double.	
3	Power Key ON.	Red Light ON.
4	Dial Telephone 840-9202 & wait for sharp tone.	
	HURRY FOR NEXT STEP!	
5	With the sharp tone, place telephone on slots in the terminal with the cord end in the correct slot as marked.	Green Light ON, indicating the terminal is connected with the host computer at NBS Institute for Computer Science & Technology (DEC PDP-10).
	HURRY FOR NEXT STEP!	
6	Depress Control Key (Marked CTRL in black at 3rd row extreme left of the keyboard) and hold while hitting C key simultaneously.	A dot appears indicating the terminal is linked satisfactorily with the host computer.
7	Type LOGIN 444,112 and hit RETURN key.	Terminal responds with messages such as: JOB 22 NBS-10 DEC 507B NBS 4/ILX TTY30 %LGNNOC No operator coverage. At the end of the message, the request for a password appears: PASSWORD:

Step	User Action	Remarks
8	Type in password and hit RETURN key.	If the password is acceptable, the terminal will deliver message of the day such as:

```
1054    20-May-77       Fri

%SCNUKS Unknown switch INITIA

Preventive Maintenance Tuesdays 8:30-12:30

5/19/77:
If the free space situation doesn't markedly improve soon, I will
start housecleaning by hand!

5/18/77:
The Mag tape drive formerly listed as down is now sort of up.
You may use it for reading (with ring OUT!), with relative safety
if not confidence.  The same does not hold true for writing.
```

Step	User Action	Remarks
		At the end of the messages, a dot should re-appear indicating the terminal is ready for action.
9	Type TTY FILL 2 and hit RETURN key.	A dot should appear again. At this point, the terminal is ready to link up with three files established for NBS Paper Physics Data File. The names and purposes of the three files are:

File Name	Calling Code	Searchable Fields (not)
NBSPPF	COLL2	NBS Number Author Keywords (title) (citation)
PPFABS	COLL3	NBS Number (abstract)
PPFVAR	COLL6	NBS Number Sample Label Primary Test Variable (Secondary Test Var.)

To begin the search, let us use keywords as the searchable field.

Appendix II - continued

Step	User Action	Remarks
10	Type EXECUTE COLL2 and hit RETURN key.	The terminal will respond with:

```
LINK:    LOADING
[LNKXCT COLLIN EXECUTION]
WELCOME TO THE COLLIN DATA BASE SYSTEM
YOU ARE ACCESSING DATA BASE NBSPPF

NUMBER OF RECORDS IN DATA BASE IS  47
MAX POSSIBLE RECORDS ARE 990
DB POINTER IS   47

DATA DEFINITION FOLLOWS
NUMBER OF DATA FIELDS DEFINED 5
SPACE TAKEN BY DATA DEF STORAGE 78
NAME NBS NUMBER
            ALPHANUMERIC.   12 CHARACTERS,   1 OCCURRENCES, SEARCH
NAME AUTHOR
            ALPHANUMERIC,   20 CHARACTERS,   4 OCCURRENCES, SEARCH
NAME TITLE
            ALPHANUMERIC.   80 CHARACTERS,   2 OCCURRENCES, NON SEARCH
NAME CITATION
            ALPHANUMERIC.   80 CHARACTERS.   2 OCCURRENCES, NON SEARCH
NAME KEYWORDS
            ALPHANUMERIC,   20 CHARACTERS,   9 OCCURRENCES. SEARCH

ACCEPTABLE COMMANDS ARE:
FIND.STORE.PRINT.END.DEFINE.DELETE-RECORD.INPUT
OUTPUT,OUTPUT-INDEX,PRINT-INDEX,UPDATE,PROMPT
```

The last line of the printout is a request for action, i.e.

```
TYPE IN FIND STORE PRINT END /ANY OTHER COMMANDS
```

Step	User Action	Remarks
11	Type FIND and hit RETURN.	The terminal will respond: ENTER FIELD YOU WISH TO FIND OR ALL
12	Type KEYWORDS and hit RETURN.	The terminal will respond: ENTER ALPHANUMERIC KEYWORDS
		At this point, the user should refer to a list of keywords (attached at the end of this manual) and select a specific one from the list for record search. For example, if one selects fiber length, then:
13	Type FIBER LENGTH and hit RETURN key.	The terminal responds with:

```
NUMBER OF RECORDS FOUND 2

TYPE IN FIND STORE PRINT END /ANY OTHER COMMANDS
```

Step	User Action	Remarks
14	Type PRINT and RETURN.	The terminal responds with:

```
**RECORD 29
*NBS NUMBER
SPECIAL 2
*AUTHOR
GRAMINSKI
FORSHEE
BOTTOMLEY
*TITLE
EVALUATION OF GILBERT CURRENCY PAPER
*CITATION
SPECIAL NBS REPORT TO BUREAU OF NGRAVING AND PRINTING WASHINGTON,D.C.
MAY 15,1966
*KEYWORDS
CURRENCY PAPERS
CURRENCY
FLEXING
DURABILITY
RHEOLOGICAL PROP.
FIBER LENGTH
PHYSICAL PROPERTIES
LOAD-ELONGATION

**RECORD 47
*NBS NUMBER
NBSIR76-1062
*AUTHOR
FONG
REHM
GRAMINSKI
etc.
```

The message will end with:

```
TYPE IN FIND STORE PRINT END /ANY OTHER COMMANDS
```

At this point, you may wish to search for other records within COLL2 (go back to step 11) or to change a file. In the latter case, we must terminate COLL2.

Appendix II - continued

Step	User Action	Remarks
15	Type END and RETURN.	The terminal will type EXIT, and a dot will appear.
16A	Type EXECUTE COLL3 and RETURN.	If one needs abstract.
or 16B	Type EXECUTE COLL6 and RETURN.	If one needs to search the fields of Sample Label or Primary Test Variables. Always refer to the list of words for each searchable field (attached at the end of this manual).
or 16C	Type K/F and RETURN.	This is to end the search. The terminal's response is something like this:

```
JOB 22, USER [444,112] LOGGED OFF TTY30    1103  20-MAY-7
SAVED ALL FILES (3115 BLOCKS)
RUNTIME 5.76 SEC
```

If steps 16A or 16B are taken, go back to step 11.

Or else, continue:

17	Unhook telephone, turn off power key.	THE END.

Appendix III

NBS Paper Physics Data File - List of Words for Searchable Fields

Name of Field:	NBS NUMBER	AUTHOR
Searchable under file name:	COLL2, COLL3	COLL2
List of Words:	NBS 3191	
	NBS 4367	BOTTOMLEY
	NBS 4509	CARTER
	NBS 4664	FONG
	NBS 4804	FORSHEE
	NBS 4964	GRAMINSKI
	NBS 5104	HOBBS
	NBS 5202	MANDEL
	NBS 5778	MILLIKEN
	NBS 6334	RANDALL
	NBS 6540	REHM
	NBS 6672	SMITH
	NBS 6932	SPECIAL REPORT
	NBS 6933	TOTH
	NBS 7089	WILSON
	NBS 7127	WORTHINGTON
	NBS 7198	
	NBS 7416	
	NBS 7561	
	NBS 7859	
	NBS 8096	
	NBS 8316	
	NBS 8514	
	NBS 8637	
	NBS 8638	
	NBS 8937	
	NBS 9035	
	NBS 9510	
	NBS 9597	
	NBS 9681	
	NBS 9859	
	NBS 10090	
	NBS 10229	
	NBS 10336	
	NBS 10465	
	NBS 10564	
	NBS 10802	
	NBS 10912	
	NBSIR 73-124	
	NBSIR 73-274	
	NBSIR 74-431	
	NBSIR 74-571	
	NBSIR 75-670	
	NBSIR 75-978	
	NBSIR76-1062	
	SPECIAL 1	
	SPECIAL 2	

Appendix III - continued

Name of Field: KEYWORDS

Searchable under file name: COLL2

List of Words:

ABRASION
ACID HYDROLYSIS
ACRYLIC LATEXES
ACRYLIC RESINS
ADDITIVES
ADHESIVENESS
AGING
AIR PERMEABILITY
AMINO ACIDS
BEATING
BINDING AGENT
BRIGHTNESS
CALENDERING
CELLULOSE DEGRAD.
COMMERCIAL PAPERS
CRUMPLING NUMBER
CURRENCY
CURRENCY PAPERS
CYCLING
DEGRADATION
DURABILITY
EDGE-TEAR
ELASTIC RECOVERY
FATIGUE
FIBER LENGTH
FITNESS
FLAT-BED PRESSES
FLEXING
FOLDING
FOLDING END.TESTER
FOLDING ENDURANCE
GELATIN
GLUCOSE
GLUE
GLUE RESIZING
GLYCEROL
HYDROXYPROLINE
INK
LOAD-ELONGATION
M-F
MANNITOL
MELAMINE RESIN
MICROSTRUCTURE
MODELLING
MODIFIED COTTON
MOISTURE
NEWSPRINT
PARCHMENT PAPERS
PHYSICAL PROPERTIES
POLYVINYL ALCOHOL
POROSITY
POSTAGE STAMPS
PRE/TEST
PRINTING
PULP CLASSIFICATION
RADIATION
RAG PULP
RAYON FIBERS
RELEASING AGENTS
RHEOLOGICAL PROP.
RIGGING BOARD
ROSIN
SCE PHOTOMICROGRAPHS
SCOTCHGARD
SILICONE COATING
SOFTENING AGENTS
SOILING
STABILITY
STANDARD DEVIATION
STATISTICAL ANALYSIS
STRESS-STRAIN
SUPERCALENDERING
SURFACE AREA
SYNTHETIC FIBERS
VINYL POLYMERS
VISCOSITY
WATER PENETRATION
WEAR QUALITIES
WET-PRESSING
WIPING PAPER
WOOD-PULP PAPERS

Appendix III - continued

Names of Fields: S-GROUP 1
S-GROUP 2
S-GROUP 3

Searchable under
file name: COLL6 (Limited to 3 Reports)

List of Words: (Sample Labels)

1970GS
1970M-2.5%PVA-A
1970M-2.5%PVA-B
1970M-5%PVA-A
1970M-CONTROL
1970M-JUV SOIL RETAR
1970M-SCOTCHGARD
1970M-S-1(0.3%Si)
1970M-S-3(0.7%Si)
1970M-S-5(0.5%Si)
1970M-S-17(3.6%Si)
1970M-S-30(4.1%Si)
1970M-Si-TYPE 104
1970M-Si-TYPE 165

1970W-2.5%PVA-A
1970W-2.5%PVA-B
1970W-5%PVA-A
1970W-CONTROL
1970W-Si-TYPE 104
1970W-Si-TYPE 165
4838-CONTROL
4838-RESIZED
4838-RESIZED-SLACK R
4998
4998-AGED 24 HOURS
4998-AGED 48 HOURS
4998-AGED 72 HOURS
4998-MELAMINE-GLYCE
4998A-MELAMINE-GLYCE
5000
5000-AGED 24 HOURS
5000-AGED 48 HOURS
5000-AGED 72 HOURS
5000-MEL-GLYCE-GLUE
5001
5001-AGED 24 HOURS
5001-AGED 48 HOURS
5001-AGED 72 HOURS
5001-MELAMINE
5001A-MELAMINE
75%DACRN/COTTON HDSH
75%NYLON/COTTON HDSH
75%ORLON/COTTON HDSH
CONTROL COTTON
DECRYST COTTON-CONTR
DECRYST COTTON-EVAPD
DECRYST COTTON-MELAM
DECRYST COTTON-WASHD
UNTREAT COTTON-CONTR
UNTREAT COTTON-MELAM

Appendix III - continued

Names of Fields:	P-GROUP 1 P-GROUP 2 P-GROUP 3
Searchable under file name:	COLL6 (Limited to 3 Reports)
List of Words:	(Primary Test Variables)

ABRASION-WEIGHT LOSS
BASIS WEIGHT
BRIGHTNESS
BURSTING STRENGTH
CRUMPL-AIR PERMEABLT
ELONGATION-%-CROSS
ELONGATION-%-MACHINE
EXPANSIVITY/15%CH-RH
FOLD ENDUR-CROSS
FOLD ENDUR-MACHINE
FREENESS
HEAT AGING-%WT LOSS
OIL(CASTOR) PENETRAT
OIL(#10) PENETRATION
OPACITY
% PICKUP-BY WEIGHT
PH-1 HOUR SOAK
PH-4 HOUR SOAK
REFLECTANCE-FELTSIDE
REFLECTANCE-WIRESIDE
SMOOTHNESS
SURFACE GLO-FELTSIDE
SURFACE GLO-WIRESIDE
TEARING STRENGTH
TEAR STR-CROSS
TEAR STR-MACHINE
TENSILE STRENGTH
TENS STR-DRY
TENS STR-DRY-CROSS
TENS STR-DRY-MACHINE
TENS STR-WET
TENS STR-WET-CROSS
TENS STR-WET-MACHINE
THICKNESS
WATER PENETRATION
WATER RESISTANCE

Appendix IV

How to Create a Data File via an NBS Experimental Data Base System

Equipment used: Digital Equipment Corp DEC-10

THE COLLIN DATA BASE SYSTEM

September 23,1976

The COLLIN Data Base System is a very user-oriented data base management system for the DEC 10. COLLIN prompts the user for all data base functions. These functions include:

.Data Definition
.Inserting new data records
.Updating data records
.Printing data records
.Deleting data records
.Printing out the index file

The unique characteristic of COLLIN is its ability to prompt the user for all functions of a data base management system consequently making COLLIN very easy to use.

The data structures supported are 1 level repeating groups with numeric or alphanumeric data fields occurring 1 to 9 times. An index file is user definable on data fields (numeric 1 to 18 digits, alphanumeric 1 to 20 characters) to facilitate searching for records.

Data field lengths can be as long as 80 characters, however to support an index on a data field requires 20 or fewer characters for an alphanumeric field.

A search or index on the data field allows rapid access to data base records without a lengthy sequential search of all the individual data base records. Only search fields can be found with the FIND command. All fields can be printed out.

1. COLLIN COMMANDS

A carriage return is an acceptable response to all commands.

FIND
Finds a particular record, set of records or all records. Prompts the user first for the field name and then the value of that field. Equality matching is supported. Only search fields can be entered with the FIND command. All records can be found with a response of ALL.

STORE
Stores a record in the data base by prompting the user to enter values in each data field, one value at a time. *CLEAR is an acceptable response to a STORE prompt and all occurrences with that data field in the record being created are cleared.

PRINT
Prints records found with the FIND command.

END
Terminates the data base session.

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DEFINE

Prints out the present data definition and prompts the user for new data definition fields:

- .Name of data definition field (30 or fewer characters)
- .Numeric or alphanumeric
- .Length of data field--18 or fewer for numeric, 80 or fewer for alphanumeric.
- .Number of occurrences within a field within a record. e.g. number of names within name field within a record. (1 to 9 occurrences are acceptable).
- .Search or non-search field (search numeric 18 or fewer characters, search alphanumeric 20 or fewer characters).

In the data definition up to 36 fields can be defined using 200 extents (system parameter for storage).

DELETE-RECORD

Deletes all records found with the FIND criteria. If the FIND criteria is ALL, the DELETE-RECORD will not delete all records (for your protection).

PRINT-INDEX

Prints out the values in the index file and the number of records containing these values. The field name is also printed. PRINT-INDEX prompts the user for a field name (must be a search field) or ALL (all search fields).

UPDATE

Updates a record. Prompts the user for the record number (system assigned value for each record).
Fields can be added in the same manner as with STORE.
If *CLEAR is a response to an update prompt for a particular field, all occurrences within that field of the update record are cleared.

OUTPUT

Performs the same function as PRINT, however the output results are written to the mass-storage file OUTPUT in place of the terminal..
In order to have the results printed on the line printer when you end your data base session, you must enter the following command in monitor mode:

```
.PRINT OUTPUT/FILE:COBOL
```

OUTPUT-INDEX

Performs the same function as PRINT-INDEX however the output results are written to the mass-storage file OUTPUT. See the description under OUTPUT in order to have the results printed on the line printer.

PROMPT

PROMPT allows the user to define which of the data definition fields will be considered in executing the PRINT, STORE, and UPDATE commands. The user is prompted to chose from:

ALL All fields will be considered
ONLY Considers only the fields that will be input

and prompts the user for those fields.
Same as CLEAR followed by ON.

ON Turns on a field for consideration.

OFF Turns off a field for consideration.

CLEAR Turns off all fields for further consideration.

After entering ALL or CLEAR, the user is again asked the prompting question to determine if fields will be turned ON or OFF.

2. System Considerations

COLLIN is written completely in COBOL, and is easily modifiable. The following are the present values. These values can be expanded.

300 data records
36 data fields using 200 extents of storage.
50 record occurrences within each value of the index table.

Setting Up the System

Login under your own number.

note:replace dbname with 6 or fewer characters you chose for your data base name. The name must be compatible with DEC 10 file name conventions i,e. no weird characters. Use upper case.

```
.COPY dbname.CBL=COLLIN.CBL[444,117]
.COPY dbname=IND1[444,117]
.COPY IND.IDA=IND1.IDA[444,117]
.SOS dbname.CBL
*SXXSdbnameS1:*
  ($ is the escape character)
  (a carriage return is required at the end of the line)
*E
.EXECUTE dbname.CBL  (initializes the system index tables)

.EXECUTE dbname.REL  (runs data base system).
```

3. Files Created

```
dbname  (index file)
IND.IDA  (index data file)
dbname.DAT    (data file)
dbname.DEF    (data definition file)
dbname.REL    (relocatable program file)
OUTPUT        (line printer temporary file)
```

After the system is initialized, you can delete the following files:

dbname.CBL

dbname.QBL

In all cases replace dbname by the data base name you desire.

Appendix IV - continued

Be sure no other file in your directory has that name. Check by a

```
.DIR dbname.*
```

4. Running the System

```
.EXECUTE dbname.REL
```

5. Printing the Results from OUTPUT and OUTPUT-INDEX

```
.PRINT OUTPUT/FILE:COBOL
```

6. Backup and Recovery

Lost data is possible without sufficient backup and recovery techniques. If records have been added or modified in the data base session, and the DEC 10 crashes during the session, there is an excellent chance of having an inconsistency between index and data files. In order to avoid having to recoup more than is necessary, the following backup procedures should be taken whenever your data base becomes too valuable to loose.

Backup

```
.COPY S1=dbname
.COPY S2=IND.IDA
.COPY S3=dbname.DAT
.COPY S4=dbname.DEF
```

To Recover data base after a crash reverse the backup procedures.

```
.COPY dbname=S1
.COPY IND.IDA=S2
.COPY dbname.DAT=S3
.COPY dbname.DEF=S4
```

GOOD LUCK

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Appendix V

NBS Paper Physics Data File - Sample Output for Individual Tape

Equipment Used:	Tektronix 4051 Graphical System.
	Tektronix 4662 Plotter.
	Tektronix 4641 Printer.
Operating System:	NBS Paper Physics Data Operating System as stored on 3M-type magnetic tape cartridge of 300K-byte capacity.
*Individual Tape:	NBS Paper Physics Data Tape as stored on 3M-type magnetic tape cartridge of 300K-byte capacity.

```
NBS PAPER PHYSICS DATA FILE   -   JEFFREY FONG AND IVAN FONG, JULY 1978

KEY  1     INPUT Info Type I (Title, Authors, Keywords)
           OUTPUT Info Type I

KEY  2     INPUT Info Type II (Primary Test Variables)
           OUTPUT Info Type II

KEY  3     INPUT Info Type III (Sample Labels, Secondary)
           OUTPUT Info Type III

KEY  4     OUTPUT Info Types I,II,III, in Matrix Format

KEY  5     INPUT Info Type IV (Data Combination Codes)
KEY  6     OUTPUT Info Type IV in Matrix Format

KEY  7     INPUT Info Type V (Test Data)
KEY  8     OUTPUT Info Type V in Table Format

KEY  9     PLOT Primary Test Variable vs. Sample Labels
KEY 10     PLOT Primary vs. Secondary Test Variables

           ****************************************

Press User Definable KEY on upper left of Keyboard to activate FUNCTION.
```

The above is a facsimile of the information flashed on the screen of the Tektronix 4051 following the pressing of the AUTO-LOAD key to activate the NBS Paper Physics Data Operating System. For a complete software listing of the Operating System, see Appendix VI.

---

*As of this reporting period, only 3 of the 47 reports in the NBS Paper Physics Data File have been stored on tapes for retrieval. We have chosen 3 such reports for implementation to illustrate the capability of this computer-aided system. The three reports are NBS 4509, NBS 4664, and NBS 4804, and their information content can be seen in the sample output given in this appendix.

Appendix V - continued

Sample Output with Key 4 and Tape for Report 4509

1. NBS REPORT NUMBER:	4509
2. NBS REPORT TITLE:	IMPROVEMENT OF CURRENCY AND STAMP PAPERS NBS REPORT TO BUREAU OF ENGRAVING & PRINTING JANUARY 27,1956
3. AUTHOR(S):	EDWIN B. RANDALL, JR.
4. KEYWORDS:	CURRENCY PAPERS CURRENCY MODIFIED COTTON SILICONE COATING GLUE RESIZING ABRASION SOILING BRIGHTNESS WEAR QUALITIES
5. SAMPLE LABELS:	S: 1) 1970GS S: 2) 1970M-CONTROL S: 3) 1970M-S-1(0.3%Si) S: 4) 1970M-S-3(0.7%Si) S: 5) 1970M-S-5(0.5%Si) S: 6) 1970M-S-17(3.6%Si) S: 7) 1970M-S-30(4.1%Si) S: 8) 1970M-Si-TYPE 104 S: 9) 1970M-Si-TYPE 165 S:10) 1970W-CONTROL S:11) 1970W-Si-TYPE 104 S:12) 1970W-Si-TYPE 165 S:13) 4838-CONTROL S:14) 4838-RESIZED S:15) 4838-RESIZED-SLACK R S:16) 4998A-MELAMINE-GLYCE S:17) 5000-MEL-GLYCE-GLUE S:18) 5001A-MELAMINE
6. PRIMARY TEST VARIABLES:	P: 1) ABRASION-WEIGHT LOSS P: 2) BASIS WEIGHT P: 3) BRIGHTNESS P: 4) CRUMPL-AIR PERMEABLT P: 5) ELONGATION-%-CROSS P: 6) ELONGATION-%-MACHINE P: 7) FOLD ENDUR-CROSS P: 8) FOLD ENDUR-MACHINE P: 9) OIL(#10) PENETRATION P:10) OPACITY P:11) SMOOTHNESS P:12) TEAR STR-CROSS P:13) TEAR STR-MACHINE P:14) TENS STR-DRY-CROSS P:15) TENS STR-DRY-MACHINE P:16) TENS STR-WET-CROSS P:17) TENS STR-WET-MACHINE P:18) THICKNESS P:19) WATER PENETRATION P:20) WATER RESISTANCE
7. SECONDARY TEST VARIABLES:	A) NUMBER OF CRUMPLES B) SILICONE COATING

(continued)

Sample Output (continued)

PRIMARY TEST VARIABLE	SAMPLE LABEL # S: 1	S: 2	S: 3	S: 4	S: 5	S: 6	S: 7	S: 8	S: 9
P: 1) ABRASION-WEIGHT LOSS									
P: 2) BASIS WEIGHT									
P: 3) BRIGHTNESS									
P: 4) CRUMPL-AIR PERMEABLT									
P: 5) ELONGATION-%-CROSS									
P: 6) ELONGATION-%-MACHINE									
P: 7) FOLD ENDUR-CROSS									
P: 8) FOLD ENDUR-MACHINE									
P: 9) OIL(#10) PENETRATION									
P:10) OPACITY									
P:11) SMOOTHNESS									
P:12) TEAR STR-CROSS									
P:13) TEAR STR-MACHINE									
P:14) TENS STR-DRY-CROSS									
P:15) TENS STR-DRY-MACHINE									
P:16) TENS STR-WET-CROSS									
P:17) TENS STR-WET-MACHINE									
P:18) THICKNESS									
P:19) WATER PENETRATION									
P:20) WATER RESISTANCE									
PRIMARY TEST VARIABLE	S: 1	S: 2	S: 3	S: 4	S: 5	S: 6	S: 7	S: 8	S: 9

S: 9 1970M-Si-TYPE 165
S: 8 1970M-Si-TYPE 104
S: 7 1970M-S-30(4.1%Si)
S: 6 1970M-S-17(3.6%Si)
S: 5 1970M-S-5(0.5%Si)
S: 4 1970M-S-3(0.7%Si)
S: 3 1970M-S-1(0.3%Si)
S: 2 1970M-CONTROL
S: 1 1970GS

A blank matrix for samples S:10 to S:18 versus P:1 to P:20 also appears as output and is not shown here for brevity.

Appendix V - continued

Sample Output with Key 4 and Tape for Report 4664

1. NBS REPORT NUMBER:	4664
2. NBS REPORT TITLE:	IMPROVEMENT OF CURRENCY AND STAMP PAPERS NBS REPORT TO BUREAU OF ENGRAVING & PRINTING MARCH 31, 1956
3. AUTHOR(S):	EDWIN B. RANDALL, JR.
4. KEYWORDS:	CURRENCY PAPERS SYNTHETIC FIBERS COTTON FIBERS AGING MOISTURE ABRASION SCOTCHGARD
5. SAMPLE LABELS:	S: 1) 1970M-JUV SOIL RETAR S: 2) 1970M-SCOTCHGARD S: 3) 4998 S: 4) 4998-AGED 24 HOURS S: 5) 4998-AGED 48 HOURS S: 6) 4998-AGED 72 HOURS S: 7) 4998-MELAMINE-GLYCE S: 8) 5000 S: 9) 5000-AGED 24 HOURS S:10) 5000-AGED 48 HOURS S:11) 5000-AGED 72 HOURS S:12) 5000-MEL-GLYCE-GLUE S:13) 5001 S:14) 5001-AGED 24 HOURS S:15) 5001-AGED 48 HOURS S:16) 5001-AGED 72 HOURS S:17) 5001-MELAMINE S:18) 75%DACRN/COTTON HDSH S:19) 75%NYLON/COTTON HDSH S:20) 75%ORLON/COTTON HDSH S:21) CONTROL COTTON S:22) DECRYST COTTON-CONTR S:23) DECRYST COTTON-EVAPD S:24) DECRYST COTTON-MELAM S:25) DECRYST COTTON-WASHD S:26) UNTREAT COTTON-CONTR S:27) UNTREAT COTTON-MELAM
6. PRIMARY TEST VARIABLES:	P: 1) BASIS WEIGHT P: 2) BURSTING STRENGTH P: 3) CRUMPL-AIR PERMEABLT P: 4) ELONGATION-%-CROSS P: 5) ELONGATION-%-MACHINE P: 6) EXPANSIVITY/15%CH-RH P: 7) FOLD ENDUR-CROSS P: 8) FOLD ENDUR-MACHINE P: 9) FREENESS P:10) HEAT AGING-%WT LOSS P:11) OIL(CASTOR) PENETRAT P:12) OIL(#10) PENETRATION P:13) PH-1 HOUR SOAK P:14) PH-4 HOUR SOAK P:15) TEARING STRENGTH P:16) TEAR STR-CROSS P:17) TEAR STR-MACHINE P:18) TENSILE STRENGTH P:19) TENS STR-DRY P:20) TENS STR-DRY-CROSS P:21) TENS STR-DRY-MACHINE P:22) TENS STR-WET P:23) TENS STR-WET-CROSS P:24) TENS STR-WET-MACHINE P:25) THICKNESS P:26) WATER RESISTANCE
7. SECONDARY TEST VARIABLES:	A) NUMBER OF CRUMPLES B) DRYING TIME C) HEAT AGING TIME D) JUVENON-DIPTIME

Sample Output with Key 4 and Tape for Report 4804

1. NBS REPORT NUMBER:	4804
2. NBS REPORT TITLE:	IMPROVEMENT OF CURRENCY AND STAMP PAPERS NBS REPORT TO BUREAU OF ENGRAVING & PRINTING AUGUST 1, 1956
3. AUTHOR(S):	EDWIN B. RANDALL, JR. ...
4. KEYWORDS:	CURRENCY PAPERS POLYVINYL ALCOHOL MELAMINE RESIN GLYCEROL GLUE SOILING
5. SAMPLE LABELS:	S: 1) 1970M-2.5%PVA-A S: 2) 1970M-2.5%PVA-B S: 3) 1970M-5%PVA-A S: 4) 1970M-CONTROL S: 5) 1970W-2.5%PVA-A S: 6) 1970W-2.5%PVA-B S: 7) 1970W-5%PVA-A S: 8) 1970W-CONTROL S: 9) 4998A-MELAMINE-GLYCE S:10) 5000-MEL-GLYCE-GLUE S:11) 5001A-MELAMINE
6. PRIMARY TEST VARIABLES:	P: 1) FOLD ENDUR-CROSS P: 2) FOLD ENDUR-MACHINE P: 3) OIL(#10) PENETRATION P: 4) % PICKUP-BY WEIGHT P: 5) REFLECTANCE-FELTSIDE P: 6) REFLECTANCE-WIRESIDE P: 7) SURFACE GLO-FELTSIDE P: 8) SURFACE GLO-WIRESIDE P: 9) TEAR STR-CROSS P:10) TEAR STR-MACHINE P:11) TENS STR-DRY-CROSS P:12) TENS STR-DRY-MACHINE P:13) TENS STR-WET-CROSS P:14) TENS STR-WET-MACHINE P:15) WATER RESISTANCE
7. SECONDARY TEST VARIABLES:	A) TIME IN DRUM

Note: Blank matrices for reports 4664 and 4804 are not shown for brevity.

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Sample Output with Key 6 and Tape for Report 4509

PRIMARY TEST VARIABLE	SAMPLE LABEL # S: 1	S: 2	S: 3	S: 4	S: 5	S: 6	S: 7	S: 8	S: 9
P: 1) ABRASION-WEIGHT LOSS	***	***	***	***	***	***	***		
P: 2) BASIS WEIGHT									
P: 3) BRIGHTNESS									
P: 4) CRUMPL-AIR PERMEABLT									
P: 5) ELONGATION-%-CROSS									
P: 6) ELONGATION-%-MACHINE									
P: 7) FOLD ENDUR-CROSS		***						2-B	4-B
P: 8) FOLD ENDUR-MACHINE		***						2-B	4-B
P: 9) OIL(#10) PENETRATION		***						2-B	4-B
P:10) OPACITY									
P:11) SMOOTHNESS									
P:12) TEAR STR-CROSS		***						2-B	4-B
P:13) TEAR STR-MACHINE		***						2-B	4-B
P:14) TENS STR-DRY-CROSS		***						2-B	4-B
P:15) TENS STR-DRY-MACHINE		***						2-B	4-B
P:16) TENS STR-WET-CROSS		***						2-B	4-B
P:17) TENS STR-WET-MACHINE		***						2-B	4-B
P:18) THICKNESS									
P:19) WATER PENETRATION									
P:20) WATER RESISTANCE		***						2-B	4-B
PRIMARY TEST VARIABLE	S: 1	S: 2	S: 3	S: 4	S: 5	S: 6	S: 7	S: 8	S: 9
	1970GS	1970M-CONTROL	1970M-S-1(0.3%Si)	1970M-S-3(0.7%Si)	1970M-S-5(0.5%Si)	1970M-S-17(3.6%Si)	1970M-S-30(4.1%Si)	1970M-Si-TYPE 104	1970M-Si-TYPE 165

(continued)

Legend:

*** indicates one data point.

2B indicates 2 data points for the primary test variable as a function of the secondary test variable B.

Sample Output (continued)

PRIMARY TEST VARIABLE	S:10	S:11	S:12	S:13	S:14	S:15	S:16	S:17	S:18
P: 1) ABRASION-WEIGHT LOSS	***			2-A	2-A	2-A	***	***	***
P: 2) BASIS WEIGHT							***	***	***
P: 3) BRIGHTNESS				***	***	***	***	***	***
P: 4) CRUMPL-AIR PERMEABLT				7-A	7-A	7-A	6-A	6-A	6-A
P: 5) ELONGATION-%-CROSS							***	***	***
P: 6) ELONGATION-%-MACHINE							***	***	***
P: 7) FOLD ENDUR-CROSS	***	3-B	3-B	***	***	***	***	***	***
P: 8) FOLD ENDUR-MACHINE	***	3-B	3-B	***	***	***	***	***	***
P: 9) OIL(#10) PENETRATION	***	3-B	3-B	***	***	***	***	***	***
P:10) OPACITY				***	***	***	***	***	***
P:11) SMOOTHNESS							***	***	***
P:12) TEAR STR-CROSS	***	3-B	3-B	***	***	***	***	***	***
P:13) TEAR STR-MACHINE	***	3-B	3-B	***	***	***	***	***	***
P:14) TENS STR-DRY-CROSS	***	3-B	3-B	***	***	***	***	***	***
P:15) TENS STR-DRY-MACHINE	***	3-B	3-B	***	***	***	***	***	***
P:16) TENS STR-WET-CROSS	***	3-B	3-B	***	***	***	***	***	***
P:17) TENS STR-WET-MACHINE	***	3-B	3-B	***	***	***	***	***	***
P:18) THICKNESS							***	***	***
P:19) WATER PENETRATION				***	***	***			
P:20) WATER RESISTANCE	***	3-B	3-B				***	***	***
PRIMARY TEST VARIABLE	S:10	S:11	S:12	S:13	S:14	S:15	S:16	S:17	S:18
SAMPLE LABEL #	1970W-CONTROL	1970W-Si-TYPE 104	1970W-Si-TYPE 165	4838-CONTROL	4838-RESIZED	4838-RESIZED-SLACK R	4998A-MELAMINE-GLYCE	5000-MEL-GLYCE-GLUE	5001A-MELAMINE

Appendix V - continued

Sample Output with Key 8 and Tape for Report 4509

(a) Data for P:9 versus all samples marked by asterisk (*):

NBS PAPER PHYSICS DATA FILE - DATA TABLE FOR REPORT # 4509

VARIABLE: OIL(#10) PENETRATION (secs.)

TEST SAMPLE (SEC. VAR. VALUE)	TEST DATA (secs.)
1970M-CONTROL	123
1970W-CONTROL	102
4838-CONTROL	163
4838-RESIZED	190
4838-RESIZED-SLACK R	215
4998A-MELAMINE-GLYCE	86
5000-MEL-GLYCE-GLUE	280
5001A-MELAMINE	117

(b) Data for P:9 versus Secondary Variable B for all samples:

NBS PAPER PHYSICS DATA FILE - DATA TABLE FOR REPORT # 4509

VARIABLE: OIL(#10) PENETRATION (secs.)
SECONDARY VARIABLE: SILICONE COATING (%)

TEST SAMPLE (SEC. VAR. VALUE)	TEST DATA (secs.)
1970M-CONTROL	123
1970M-Si-TYPE 104 (0.5)	203
1970M-Si-TYPE 104 (0.7)	204
1970M-Si-TYPE 165 (0.3)	264
1970M-Si-TYPE 165 (0.6)	177
1970M-Si-TYPE 165 (2.5)	570
1970M-Si-TYPE 165 (4)	600
1970W-CONTROL	102
1970W-Si-TYPE 104 (0.44)	94
1970W-Si-TYPE 104 (0.8)	100
1970W-Si-TYPE 104 (1.4)	105
1970W-Si-TYPE 165 (0.4)	120
1970W-Si-TYPE 165 (0.8)	135
1970W-Si-TYPE 165 (1.1)	117
4838-CONTROL	163
4838-RESIZED	190
4838-RESIZED-SLACK R	215
4998A-MELAMINE-GLYCE	86
5000-MEL-GLYCE-GLUE	280
5001A-MELAMINE	117

c) Data for P:4 versus Secondary Variable A for all samples:

NBS PAPER PHYSICS DATA FILE - DATA TABLE FOR REPORT # 4509

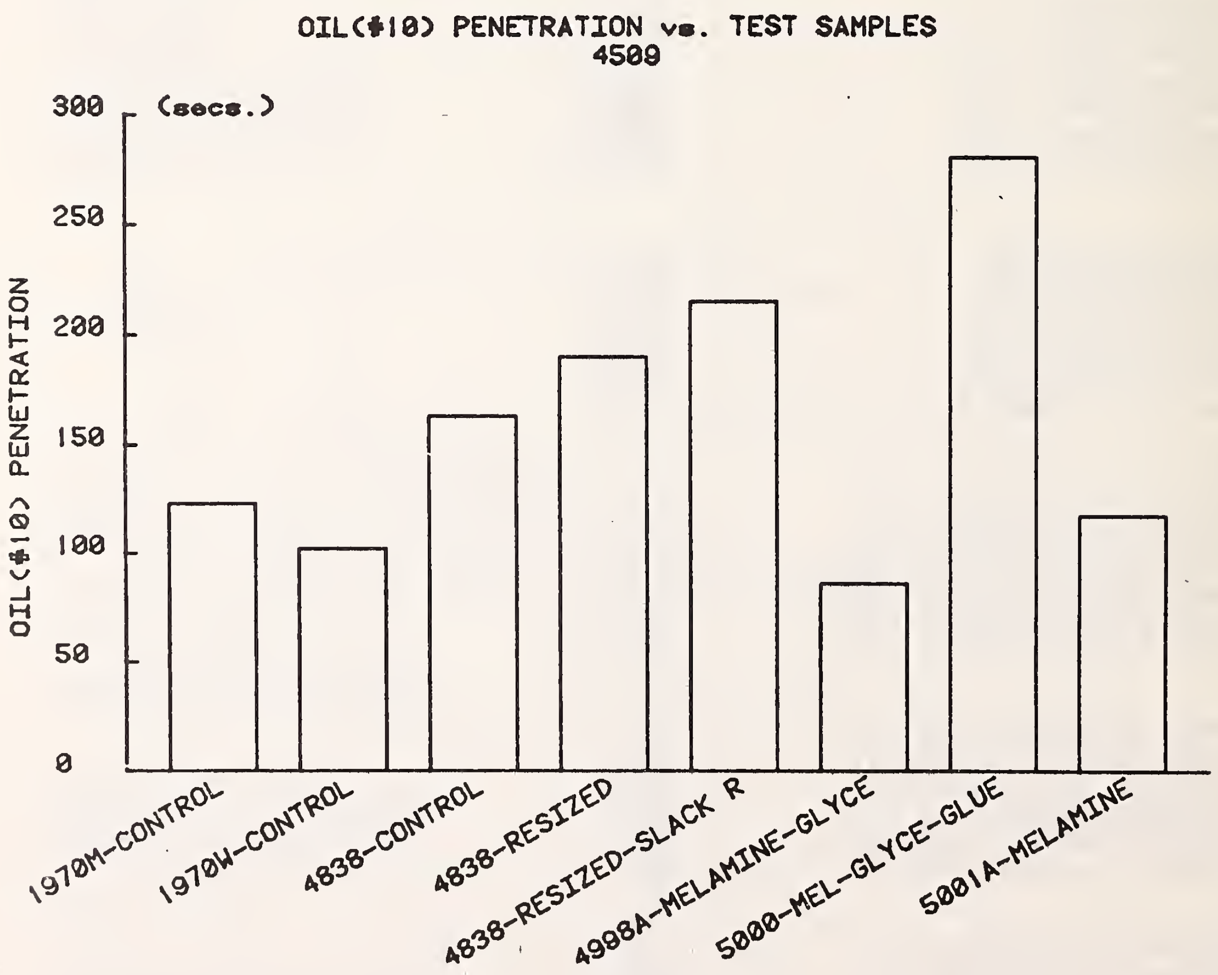
VARIABLE: CRUMPL-AIR PERMEABLT (Carson Test Units)
SECONDARY VARIABLE: NUMBER OF CRUMPLES

TEST SAMPLE (SEC. VAR. VALUE)	TEST DATA (Carson Test Units)
4838-CONTROL (0)	2.6
4838-CONTROL (4)	54
4838-CONTROL (8)	117.5
4838-CONTROL (12)	179.5
4838-CONTROL (16)	245.8
4838-CONTROL (20)	306.2
4838-CONTROL (24)	367.3
4838-RESIZED (0)	1.4
4838-RESIZED (4)	37.7
4838-RESIZED (8)	88.7
4838-RESIZED (12)	144.7
4838-RESIZED (16)	212.3
4838-RESIZED (20)	262.8
4838-RESIZED (24)	314.5
4838-RESIZED-SLACK R (0)	1.1
4838-RESIZED-SLACK R (4)	35
4838-RESIZED-SLACK R (8)	87.3
4838-RESIZED-SLACK R (12)	144.4
4838-RESIZED-SLACK R (16)	202.6
4838-RESIZED-SLACK R (20)	256.4
4838-RESIZED-SLACK R (24)	314.4
4998A-MELAMINE-GLYCE (0)	6.03
4998A-MELAMINE-GLYCE (4)	47.1
4998A-MELAMINE-GLYCE (8)	97.2
4998A-MELAMINE-GLYCE (12)	150
4998A-MELAMINE-GLYCE (16)	200
4998A-MELAMINE-GLYCE (24)	255
5000-MEL-GLYCE-GLUE (0)	1.16
5000-MEL-GLYCE-GLUE (4)	22.7
5000-MEL-GLYCE-GLUE (8)	55.5
5000-MEL-GLYCE-GLUE (12)	92.6
5000-MEL-GLYCE-GLUE (16)	133
5000-MEL-GLYCE-GLUE (24)	176
5001A-MELAMINE (0)	3.83
5001A-MELAMINE (4)	34.7
5001A-MELAMINE (8)	76.5
5001A-MELAMINE (12)	124
5001A-MELAMINE (16)	169
5001A-MELAMINE (24)	214

Appendix V - continued

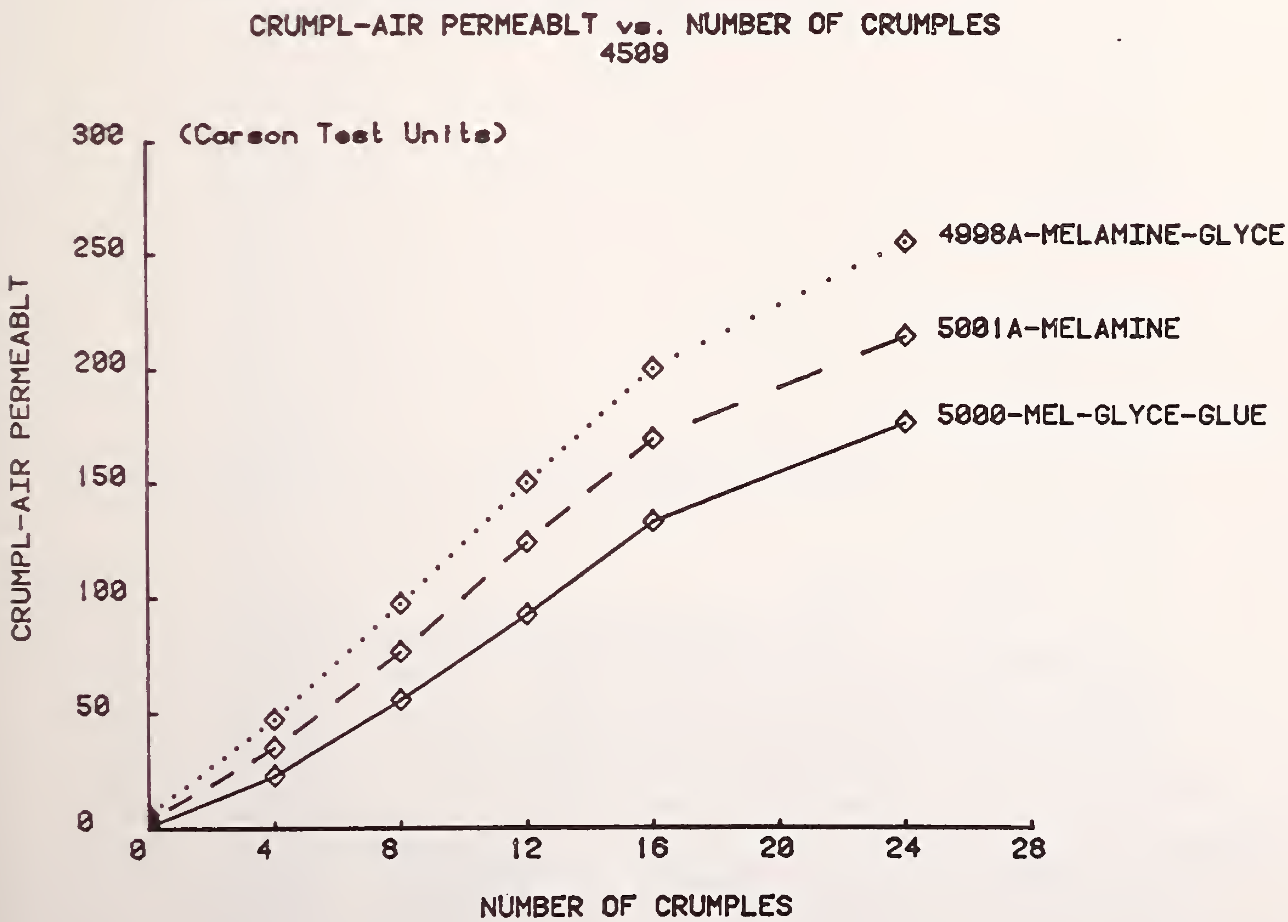
<u>Sample Output with Key 9 and Tape for Report 4509</u>

Plot for P:9 versus all samples marked with an asterisk (*):



Sample Output with Key 10 and Tape for Report 4509

Plot for P:4 versus Secondarv Variable A for 3 samples:



Appendix VI

NBS Paper Physics Data Operating System - Listing of Program in BASIC

For list of keys, See Appendix V.

To Operate Function Key Menu Display

```
1 GO TO 100
4 F=1
5 GO TO 330
8 F=2
9 GO TO 330
12 F=3
13 GO TO 330
16 F=4
17 GO TO 330
20 F=5
21 GO TO 330
24 F=6
25 GO TO 330
28 F=7
29 GO TO 330
32 F=8
33 GO TO 330
36 F=9
37 GO TO 330
40 F=10
41 GO TO 330
100 INIT
110 SET KEY
120 PRINT 'L___ NBS PAPER PHYSICS DATA FILE   -    ';
130 PRINT 'JEFFREY FONG AND IVAN FONG, JULY 1978____IHHHHHHHH';
140 PRINT 'KEY  1     INPUT Info Type I (Title, Authors, Keywords)'
150 PRINT 'I   OUTPUT Info Type I__IHHHHHHHH';
160 PRINT 'KEY  2     INPUT Info Type II (Primary Test Variables)'
170 PRINT 'I   OUTPUT Info Type II__IHHHHHHHH';
180 PRINT 'KEY  3     INPUT Info Type III (Sample Labels, Secondary)'
190 PRINT 'I   OUTPUT Info Type III__IHHHHHHHH';
200 PRI 'KEY  4     OUTPUT Info Types I,II,III, in Matrix Format__IHH';
210 PRINT 'HHHHHHKEY  5     INPUT Info Type IV (Data Combination Codes)'
220 PRINT 'IHHHHHHHHKEY  6     OUTPUT Info Type IV in Matrix Format'
230 PRINT '_IHHHHHHHHKEY  7     INPUT Info Type V (Test Data)'
240 PRINT 'IHHHHHHHHHKEY  8     OUTPUT Info Type V in Table Format__IHH';
250 PRI 'HHHHHHKEY  9     PLOT Primary Test Variable vs. Sample Labels'
260 PRI 'IHHHHHHHHKEY 10     PLOT Primary vs. Secondary Test Variables'
270 PRINT '___             ====================================='
280 PRINT 'JPress User Definable KEY on upper left of Keyboard to ';
290 PRINT 'activate FUNCTION.GGG'
300 FOR Z=1 TO 10000 STEP 0.01
310 NEXT Z
320 END
330 PRINT 'L___FUNCTION KEY ';F;' CHOSEN.GG__'
340 GO TO F OF 350,390,430,470,490,530,570,570,570,570
350 PRINT 'DO YOU WISH TO (1) STORE, (2) DISPLAY, OR (3) PRINT : ';
360 INPUT F1
370 F9=F+F1
380 GO TO 580
390 PRINT 'DO YOU WISH TO (1) STORE, (2) DISPLAY, OR (3) PRINT : ';
400 INPUT F1
410 F9=F+F1+2
420 GO TO 580
```

Appendix VI - continued

```
430 PRINT "DO YOU WISH TO (1) STORE, (2) DISPLAY, OR (3) PRINT : ";
440 INPUT F1
450 F9=F+F1+4
460 GO TO 580
470 F9=F+7
480 GO TO 580
490 PRINT "ARE YOUR CODES (1) ALPHANUMERIC, OR (2) NUMERIC : ";
500 INPUT F1
510 F9=F+F1+6
520 GO TO 580
530 PRINT "IS YOUR MATRIX (1) ALPHANUMERIC, OR (2) NUMERIC : ";
540 INPUT F1
550 F9=F+F1+7
560 GO TO 580
570 F9=F+9
580 FIND F9
590 OLD
600 RUN
610 END
```

To Operate Key 1-A

```
100 INIT
110 PRINT "LJ     NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE I"
120 PRINT "JJ      ** PLEASE INSERT A DATA TAPE FOR DATA STORAGE **"
130 PRINT "                  [RETURN]G TO CONTINUE.....................";
140 INPUT Z$
150 FIND 0
160 IF TYP(0)=2 THEN 120
170 IF TYP(0)<>0 THEN 250
180 MARK 3,2500
190 FIND 4
200 MARK 2,7500
210 FIND 6
220 MARK 1,2500
230 FIND 7
240 MARK 3,7500
250 FIND 1
260 PRINT "JJ1. NBS REPORT NUMBER:G"
270 PRINT "      ";
280 INPUT N
290 PRINT "_2. NBS REPORT TITLE:G"
300 PRINT "      ";
310 INPUT A$
320 PRINT "      ";
330 INPUT B$
340 PRINT "      ";
350 INPUT C$
360 PRINT "_3. AUTHOR(S):G"
370 PRINT "      ";
380 INPUT D$
390 PRINT "      ";
400 INPUT E$
410 WRITE N,A$,B$,C$,D$,E$
420 PRINT "_4. KEYWORDS:  [Type END when done listing]G"
430 PRINT "      ";
440 INPUT Z$
450 IF Z$="END" THEN 480
460 WRITE Z$
470 GO TO 430
480 PRINT "___         ** DATA STORED **GGG"
490 PRINT "_   INSERT MASTER TAPE FOR MENU (USE AUTO-LOAD)";
500 END
```

Appendix VI - continued

To Operate Key 1-B

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE I'
120 PRINT '_____      PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '          [RETURN] TO CONTINUEGG...........................';
140 INPUT Z$
150 FIND 1
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,A$,B$,C$,D$,E$,Z$
180 LET Z1=32
190 PRINT @Z1:'L     NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE I'
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:'1. NBS REPORT NUMBER:   ';N
240 PRINT @Z1:
250 PRINT @Z1:'2. NBS REPORT TITLE:    ';A$
260 PRINT @Z1:'                        ';B$
270 PRINT @Z1:'                        ';C$
280 PRINT @Z1:
290 PRINT @Z1:'3. AUTHOR(S):           ';D$
300 PRINT @Z1:'                        ';E$
310 PRINT @Z1:
320 PRINT @Z1:'4. KEYWORDS:            ';Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @Z1:'                        ';Z$
360 GO TO 330
370 PRINT '___        ** DATA RETRIEVED **GGG'
380 PRINT '_    RETURN TO MASTER TAPE FOR DATA STORAGE (USE AUTO-LOAD)';
390 END
```

To Operate Key 1-C

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE I'
120 PRINT '_____      PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '          [RETURN] TO CONTINUEGG...........................';
140 INPUT Z$
150 FIND 1
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,A$,B$,C$,D$,E$,Z$
180 LET Z1=41
190 PRINT @Z1:'L     NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE I'
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:'1. NBS REPORT NUMBER:   ';N
240 PRINT @Z1:
250 PRINT @Z1:'2. NBS REPORT TITLE:    ';A$
260 PRINT @Z1:'                        ';B$
270 PRINT @Z1:'                        ';C$
280 PRINT @Z1:
290 PRINT @Z1:'3. AUTHOR(S):           ';D$
300 PRINT @Z1:'                        ';E$
310 PRINT @Z1:
320 PRINT @Z1:'4. KEYWORDS:            ';Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @Z1:'                        ';Z$
360 GO TO 330
370 PRINT '___        ** DATA RETRIEVED **GGG'
380 PRINT '_    RETURN TO MASTER TAPE FOR DATA STORAGE (USE AUTO-LOAD)';
390 END
```

Appendix VI - continued

To Operate Key 2-A

```
100 INIT
110 PRINT 'LJ     NBS PAPER PHYSICS DATA FILE   -  INFORMATION TYPE II'
120 PRINT 'JJ      ** PLEASE INSERT THE DATA TAPE FOR DATA STORAGE **'
130 PRINT '               [RETURN]G TO CONTINUE.....................';
140 INPUT Z$
150 FIND 2
160 IF TYP(0)<>2 THEN 180
170 GO TO 120
180 KILL 2
190 FIND 2
200 PRINT 'JJ1. NBS REPORT NUMBER:G'
210 PRINT '      ';
220 INPUT N
230 WRITE N
240 PRINT '_2. PRIMARY TEST VARIABLES:  [Type END when done listing]G'
250 PRINT '      ';
260 INPUT Z$
270 IF Z$='END' THEN 300
280 WRITE Z$
290 GO TO 250
300 PRINT '___          ** DATA STORED **GGG'
310 PRINT '_    INSERT MASTER TAPE FOR MENU (USE AUTO-LOAD)';
320 END
```

To Operate Key 2-B

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE   -  INFORMATION TYPE II'
120 PRINT '_____      PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '         [RETURN] TO CONTINUEGG...........................';
140 INPUT Z$
150 FIND 2
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,Z$
180 LET Z1=32
190 PRI @Z1:'L      NBS PAPER PHYSICS DATA FILE   -  INFORMATION TYPE II'
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:'1. NBS REPORT NUMBER:           ';N
240 PRINT @Z1:
250 PRINT @Z1:'2. PRIMARY TEST VARIABLES:    ';Z$
260 IF TYP(0)=1 THEN 300
270 READ @33:Z$
280 PRINT @Z1:'                              ';Z$
290 GO TO 260
300 PRINT '___          ** DATA RETRIEVED **GGG'
310 PRINT '_    RETURN TO MASTER TAPE FOR DATA STORAGE (USE AUTO-LOAD)';
320 END
```

Appendix VI - continued

To Operate Key 2-C

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE   -   INFORMATION TYPE II'
120 PRINT '_____       PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '          [RETURN] TO CONTINUEGG............................';
140 INPUT Z$
150 FIND 2
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,Z$
180 LET Z1=41
190 PRI @Z1:'L      NBS PAPER PHYSICS DATA FILE   -   INFORMATION TYPE II'
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:'1. NBS REPORT NUMBER:          ';N
240 PRINT @Z1:
250 PRINT @Z1:'2. PRIMARY TEST VARIABLES:    ';Z$
260 IF TYP(0)=1 THEN 300
270 READ @33:Z$
280 PRINT @Z1:'                               ';Z$
290 GO TO 260
300 PRINT '___           ** DATA RETRIEVED **GGS'
310 PRINT '_    RETURN TO MASTER TAPE FOR DATA STORAGE (USE AUTO-LOAD)';
320 END
```

To Operate Key 3-A

```
100 INIT
110 PRINT 'LJ     NBS PAPER PHYSICS DATA FILE   -   INFORMATION TYPE III'
120 PRINT 'JJ        ** PLEASE INSERT THE DATA TAPE FOR DATA STORAGE **'
130 PRINT '                     [RETURN]G TO CONTINUE.....................';
140 INPUT Z$
150 FIND 3
160 IF TYP(0)<>2 THEN 180
170 GO TO 120
180 KILL 3
190 FIND 3
200 PRINT 'JJ1. NBS REPORT NUMBER:G'
210 PRINT '      ';
220 INPUT N
230 PRINT '_2. NUMBER OF COLUMNS FOR MATRIX OUTPUT (CHECK NUMBER OF ';
240 PRINT 'SAMPLE LABELS,_   NO MORE THAN 12 COLUMNS ONLY):  ';
250 INPUT M
260 WRITE M
270 PRINT '_3. SAMPLE LABELS:  [Type END when done listing]G'
280 PRINT '      ';
290 INPUT Z$
300 WRITE Z$
310 IF Z$='END' THEN 330
320 GO TO 280
330 PRINT '_4. SECONDARY TEST VARIABLES (WITH UNITS):  [END]G'
340 PRINT '      ';
350 INPUT Z$
360 IF Z$='END' THEN 390
370 WRITE Z$
380 GO TO 340
390 PRINT '___           ** DATA STORED **GGG';
400 PRINT '_   INSERT MASTER TAPE FOR MENU (USE AUTO-LOAD)';
410 END
```

Appendix VI - continued

To Operate Key 3-B

```
100 INIT
110 PRINT "LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE III"
120 PRINT "_____       PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,"
130 PRINT "           [RETURN] TO CONTINUEGG..........................";
140 INPUT Z$
150 FIND 3
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,Z$
180 LET Z1=32
190 PRI @Z1:"L      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE III"
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:"1. NBS REPORT NUMBER:          ";N
240 PRINT @Z1:
250 PRINT @Z1:"2. SAMPLE LABELS:              ";Z$
260 READ @33:Z$
270 IF Z$="END" THEN 300
280 PRINT @Z1:"                               ";Z$
290 GO TO 260
300 PRINT @Z1:
310 READ @33:Z$
320 PRINT @Z1:"3. SECONDARY TEST VARIABLES: ";Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @Z1:"                               ";Z$
360 GO TO 330
370 PRINT "___          ** DATA RETRIEVED **GGG"
380 PRINT "_     RETURN TO MASTER TAPE FOR DATA STRUCTURE (AUTO-LOAD)";
390 END
```

To Operate Key 3-C

```
100 INIT
110 PRINT "LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE III"
120 PRINT "_____       PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,"
130 PRINT "           [RETURN] TO CONTINUEGG..........................";
140 INPUT Z$
150 FIND 3
160 IF TYP(0)<>3 THEN 120
170 READ @33:N,Z$
180 LET Z1=41
190 PRI @Z1:"L      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE III"
200 PRINT @Z1:
210 PRINT @Z1:
220 PRINT @Z1:
230 PRINT @Z1:"1. NBS REPORT NUMBER:          ";N
240 PRINT @Z1:
250 PRINT @Z1:"2. SAMPLE LABELS:              ";Z$
260 READ @33:Z$
270 IF Z$="END" THEN 300
280 PRINT @Z1:"                               ";Z$
290 GO TO 260
300 PRINT @Z1:
310 READ @33:Z$
320 PRINT @Z1:"3. SECONDARY TEST VARIABLES: ";Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @Z1:"                               ";Z$
360 GO TO 330
370 PRINT "___          ** DATA RETRIEVED **GGG"
380 PRINT "_     RETURN TO MASTER TAPE FOR DATA STRUCTURE (AUTO-LOAD).";
390 END
```

Appendix VI - continued

To Operate Key 4

```
100 INIT
110 PRI 'LJJ      NBS PAPER PHYSICS DATA FILE   -  INFO. TYPES I, II, III'
120 PRINT '_____        PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '            [RETURN] TO CONTINUEGG.........................';
140 INPUT Z$
150 FIND 1
160 IF TYP(0)=3 THEN 180
170 GO TO 120
180 READ @33:N,A$,B$,C$,D$,E$,Z$
190 PRI @41:'L     NBS PAPER PHYSICS DATA FILE  - INFO. TYPES I, II, III'
200 PRINT @41:
210 PRINT @41:
220 PRINT @41:
230 PRINT @41:'1. NBS REPORT NUMBER:            ';N
240 PRINT @41:
250 PRINT @41:'2. NBS REPORT TITLE:             ';A$
260 PRINT @41:'                                 ';B$
270 PRINT @41:'                                 ';C$
280 PRINT @41:
290 PRINT @41:'3. AUTHOR(S):                    ';D$
300 PRINT @41:'                                 ';E$
310 PRINT @41:
320 PRINT @41:'4. KEYWORDS:                     ';Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @41:'                                 ';Z$
360 GO TO 330
370 PRINT @41:
380 PRINT @41:
390 FIND 3
400 READ @33:M,Z$
410 C1=1
420 PRINT @41:'5. SAMPLE LABELS:                S: 1) ';Z$
430 READ @33:Z$
440 IF Z$='END' THEN 510
450 C1=C1+1
460 PRINT @41:'                                 S:';
470 PRINT @41: USING 490:C1
480 PRINT @41:') ';Z$
490 IMAGE 2D,S
500 GO TO 430
510 PRINT @41:
520 FIND 2
530 READ @33:N1,Z$
540 IF N1<>N THEN 1630
550 C2=1
560 PRINT @41:'6. PRIMARY TEST VARIABLES:       P: 1) ';Z$
570 IF TYP(0)=1 THEN 640
580 C2=C2+1
590 READ @33:Z$
600 PRINT @41:'                                 P:';
610 PRINT @41: USING 490:C2
620 PRINT @41:') ';Z$
630 GO TO 570
640 PRINT @41:
650 FIND 3
660 READ @33:M,Z$
670 FOR I=1 TO C1+1
680 READ @33:Z$
690 NEXT I
```

Appendix VI - continued

```
700 C3=1
710 GOSUB 1150
720 PRINT @41:"7. SECONDARY TEST VARIABLES:    A) ";Y$
730 IF TYP(0)=1 THEN 810
740 C3=C3+1
750 READ @33:Z$
760 GOSUB 1150
770 X$=CHR(C3+64)
780 PRINT @41:"                                         ";X$;
790 PRINT @41:") ";Y$
800 GO TO 730
810 FOR L=1 TO 6
820 PRINT @41:
830 NEXT L
840 PRINT @41:"        NBS PAPER PHYSICS DATA FILE  -  DATA MATRIX FOR ";
850 PRINT @41:"REPORT # ";N
860 PRINT @41:
870 PRINT @41:
880 K=INT(C1/(M+1))
890 K1=0
900 PRINT @41:"                                     (H)  SAMPLE LABEL #"
910 GOSUB 1480
920 PRINT @41:
930 GOSUB 1210
940 FIND 2
950 READ @33:N2
960 FOR J=1 TO C2
970 READ @33:Z$
980 PRINT @41:"  P:";
990 PRINT @41: USING 490:J
1000 GOSUB 1290
1010 NEXT J
1020 GOSUB 1210
1030 GOSUB 1480
1040 PRINT @41:
1050 GOSUB 1560
1060 FOR L=1 TO 4
1070 PRINT @41:
1080 NEXT L
1090 IF K1=K THEN 1120
1100 K1=K1+1
1110 GO TO 900
1120 PRI "-----        MARK THOSE BOXES WHICH CORRESPOND TO DATA VALUES,"
1130 PRI "         RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).";
1140 END
1150 Y=POS(Z$,"(",1)
1160 IF Y<>0 THEN 1190
1170 Y$=Z$
1180 GO TO 1200
1190 Y$=SEG(Z$,1,Y-1)
1200 RETURN
1210 PRINT @41:"==============================(H)H======";
1220 IF M=1 THEN 1270
1230 FOR I=K1*M+1 TO (K1+1)*M
1240 PRINT @41:"=H!=====";
1250 IF I=C1-1 OR I=(K1+1)*M-1 THEN 1270
1260 NEXT I
1270 PRINT @41:"=H!"
1280 RETURN
1290 PRINT @41:") -";Z$;
1300 FOR S=1 TO 21-LEN(Z$)
1310 PRINT @41:" ";
1320 NEXT S
1330 PRINT @41:"(H)     ";
1340 IF M=1 THEN 1390
1350 FOR I=K1*M+1 TO (K1+1)*M
1360 PRINT @41:"!      ";
1370 IF I=C1-1 OR I=(K1+1)*M-1 THEN 1390
1380 NEXT I
1390 PRINT @41:"!"
1400 IF J=C2 THEN 1470
1410 PRINT @41:"------------------------------(H)H------";
1420 FOR I=K1*M+1 TO (K1+1)*M
1430 PRINT @41:"-H!-----";
```

Appendix VI - continued

```
1440 IF I=C1-1 OR I=(K1+1)*M-1 THEN 1460
1450 NEXT I
1460 PRINT @41:"-H!"
1470 RETURN
1480 PRINT @41:"    PRIMARY TEST VARIABLE    (H) S:";
1490 FOR I=K1*M+1 TO (K1+1)*M
1500 PRINT @41: USING 490:I
1510 IF I=C1 OR I=(K1+1)*M THEN 1540
1520 PRINT @41:"! S:";
1530 NEXT I
1540 PRINT @41:"!";
1550 RETURN
1560 IF K1=K THEN 1590
1570 FOR I=(K1+1)*M TO K1*M+1 STEP -1
1580 GO TO 1600
1590 FOR I=C1 TO K1*M+1 STEP -1
1600 FIND 3
1610 READ @33:N1
1620 FOR J=1 TO I
1630 READ @33:Z$
1640 NEXT J
1650 PRINT @41:"                              (H) ";
1660 IF I=K1*M+1 THEN 1700
1670 FOR H=1 TO I-K1*M-1
1680 PRINT @41:"    ! ";
1690 NEXT H
1700 PRINT @41:Z$
1710 NEXT I
1720 RETURN
1730 PRINT "___     ERROR IN REPORT NUMBER.  PLEASE VERIFYGG,__"
1740 GO TO 1130
```

To Operate Key 5-A

```
100 INIT
110 PRINT "LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE IV"
120 PRINT "__        PLEASE INSERT THE DATA TAPE FOR DATA STORAGE,"
130 PRINT "           [RETURN] TO CONTINUEGG..........................";
140 INPUT A$
150 PRINT "__        KILL EXISTING FILE?  [Y OR N]:  ";
160 INPUT A$
170 IF A$="N" THEN 250
180 FIND 4
190 IF TYP(0)=2 THEN 120
200 MARK 2,7500
210 FIND 6
220 MARK 1,2500
230 FIND 7
240 MARK 3,7500
250 K1=0
260 P=0
270 FIND 3
280 READ @33:M
290 FIND 2
300 READ @33:N
310 PRINT "L__1. NBS REPORT NUMBER:G       ";N
320 PRINT
330 PRINT "2. DATA COMBINATION CODES:G  TYPE INFORMATION TO BE STORED ";
340 PRINT "(<4 CHAR.)."
350 READ @33:Z$
360 FIND 4
370 IF TYP(0)=0 OR TYP(0)=1 THEN 400
380 READ @33:B$
390 GO TO 370
400 P=P+1
410 PRINT "_P:";
420 PRINT USING 430:P
430 IMAGE 2D,S
440 PRINT ") ";Z$;"G"
450 FOR J=K1*M+1 TO (K1+1)*M
```

Appendix VI - continued

```
460 PRINT "IS:";
470 PRINT USING 430:J
480 PRINT ") ";
490 DIM C$(3)
500 INPUT C$
510 IF C$<>"" THEN 530
520 C$="   "
530 WRITE C$
540 NEXT J
550 FIND 2
560 READ @33:N
570 FOR I=1 TO P
580 READ @33:Z$
590 NEXT I
600 IF TYP(0)=1 THEN 620
610 GO TO 310
620 PRINT "__END OF FILE?  [Y OR N]:  ";
630 INPUT A$
640 IF A$="Y" THEN 670
650 K1=K1+1
660 GO TO 260
670 PRINT "____            ** DATA STORED **GGG"
680 PRI "           RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).";
690 END
```

To Operate Key 5-B

```
100 INIT
110 PRINT "LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE IV"
120 PRINT "__        PLEASE INSERT THE DATA TAPE FOR DATA STORAGE,"
130 PRINT "           [RETURN] TO CONTINUEGG..........................";
140 INPUT A$
150 PRINT "__        KILL EXISTING FILE?  [Y OR N]:  ";
160 INPUT A$
170 IF A$="N" THEN 250
180 FIND 5
190 IF TYP(0)=2 THEN 120
200 MARK 1,7500
210 FIND 6
220 MARK 1,2500
230 FIND 7
240 MARK 3,7500
250 K1=0
260 P=0
270 S=0
280 FIND 2
290 READ @33:N
300 READ @33:Z$
310 P=P+1
320 IF TYP(0)<>1 THEN 300
330 FIND 3
340 READ @33:M
350 READ @33:Z$
360 S=S+1
370 IF Z$<>"END" THEN 350
380 S=S-1
390 GOSUB 670
400 DIM D(P,S)
410 FIND 5
420 FOR I=1 TO P
430 PRINT "_P:";
440 PRINT USING 450:I
450 IMAGE 2D,S
460 PRINT ")G";
470 FOR J=K1*M+1 TO (K1+1)*M
480 PRINT "IS:";
490 PRINT USING 450:J
```

Appendix VI - continued

```
500 PRINT ') ';
510 INPUT D$
520 IF D$<>'' THEN 540
530 D$='0'
540 D(I,J)=VAL(D$)
550 WRITE D(I,J)
560 NEXT J
570 GOSUB 670
580 NEXT I
590 PRINT '__END OF FILE?  [Y OR N]:   ';
600 INPUT A$
610 IF A$='Y' THEN 640
620 K1=K1+1
630 GO TO 420
640 PRINT '____            ** DATA STORED **GGG'
650 PRI '          RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).';
660 END
670 PRINT 'L__1. NBS REPORT NUMBER:G       ';N
680 PRINT
690 PRINT '2. DATA COMBINATION CODES:G  TYPE NUMERIC DATA TO BE STORED';
700 PRINT ' (<4 CHAR.).'
710 RETURN
```

To Operate Key 6-A

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE   -  INFO. TYPES I, IV'
120 PRINT '_____        PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '           [RETURN] TO CONTINUE[G.........................';
140 INPUT Z$
150 FIND 1
160 IF TYP(0)=3 THEN 180
170 GO TO 120
180 READ @33:N,A$,B$,C$,D$,E$,Z$
190 PRINT @41:'L    NBS PAPER PHYSICS DATA FILE  - INFO. TYPES I, IV'
200 PRINT @41:
210 PRINT @41:
220 PRINT @41:
230 PRINT @41:'1. NBS REPORT NUMBER:              ';N
240 PRINT @41:
250 PRINT @41:'2. NBS REPORT TITLE:               ';A$
260 PRINT @41:'                                   ';B$
270 PRINT @41:'                                   ';C$
280 PRINT @41:
290 PRINT @41:'3. AUTHOR(S):                      ';D$
300 PRINT @41:'                                   ';E$
310 PRINT @41:
320 PRINT @41:'4. KEYWORDS:                       ';Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @41:'                                   ';Z$
360 GO TO 330
370 PRINT @41:
380 PRINT @41:
390 PRINT @41:
400 FIND 2
410 READ @33:N1,Z$
420 C2=1
430 IF TYP(0)=1 THEN 470
440 READ @33:Z$
450 C2=C2+1
460 GO TO 430
```

Appendix VI - continued

```
470 FIND 3
480 READ @33:M,Z$
490 C1=1
500 READ @33:Z$
510 IF Z$='END' THEN 540
520 C1=C1+1
530 GO TO 500
540 PRINT @41:'        NBS PAPER PHYSICS DATA FILE  -  DATA MATRIX FOR ';
550 PRINT @41:'REPORT # ';N
560 PRINT @41:
570 PRINT @41:
580 K=INT(C1/(M+1))
590 K1=0
600 PRINT @41:'                                           (H)  SAMPLE LABEL #'
610 GOSUB 1270
620 PRINT @41:
630 GOSUB 850
640 FIND 2
650 READ @33:N1
660 FOR J=1 TO C2
670 READ @33:Z$
680 PRINT @41:'  P:';
690 PRINT @41: USING 1300:J
700 GOSUB 920
710 NEXT J
720 GOSUB 850
730 GOSUB 1270
740 PRINT @41:
750 GOSUB 1360
760 FOR L=1 TO 4
770 PRINT @41:
780 NEXT L
790 IF K1=K THEN 820
800 K1=K1+1
810 GO TO 600
820 PRI '-----        MARK THOSE BOXES WHICH CORRESPOND TO DATA VALUES,'
830 PRI '         RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).';
840 END

850 PRINT @41:'=============================(H)H======';
860 FOR I=K1*M+1 TO (K1+1)*M
870 PRINT @41:'=H!=====';
880 IF I=C1-1 OR I=(K1+1)*M-1 THEN 900
890 NEXT I
900 PRINT @41:'=H!'
910 RETURN
920 PRINT @41:') ';Z$;
930 FOR S=1 TO 21-LEN(Z$)
940 PRINT @41:' ';
950 NEXT S
960 PRINT @41:'(H)';
970 FIND 4
980 IF J=1 AND K1=0 THEN 1020
990 FOR I=1 TO K1*C2*M+(J-1)*M
1000 READ @33:B$
1010 NEXT I
1020 FOR I=1 TO M
1030 READ @33:C$
1040 FOR S=1 TO INT((5-LEN(C$))/2)
1050 PRINT @41:' ';
1060 NEXT S
1070 PRINT @41:C$;
1080 FOR S=1 TO INT((6-LEN(C$))/2)
1090 PRINT @41:' ';
1100 NEXT S
1110 PRINT @41:'!';
1120 NEXT I
```

Appendix VI - continued

```
1130 PRINT @41:
1140 IF J=C2 THEN 1260
1150 PRINT @41:'------------------------------(H)H------';
1160 FOR I=K1*M+1 TO (K1+1)*M
1170 PRINT @41:'-H!-----';
1180 IF I=C1-1 OR I=(K1+1)*M-1 THEN 1200
1190 NEXT I
1200 PRINT @41:'-H!'
1210 FIND 2
1220 READ @33:N1
1230 FOR J1=1 TO J
1240 READ @33:Z$
1250 NEXT J1
1260 RETURN
1270 PRINT @41:'     PRIMARY TEST VARIABLE     (H) S:';
1280 FOR I=K1*M+1 TO (K1+1)*M
1290 PRINT @41: USING 1300:I
1300 IMAGE 2D,S
1310 IF I=C1 OR I=(K1+1)*M THEN 1340
1320 PRINT @41:'! S:';
1330 NEXT I
1340 PRINT @41:'!';
1350 RETURN
1360 IF K1=K THEN 1390
1370 FOR I=(K1+1)*M TO K1*M+1 STEP -1
1380 GO TO 1400
1390 FOR I=C1 TO K1*M+1 STEP -1
1400 FIND 3
1410 READ @33:M
1420 FOR J=1 TO I
1430 READ @33:Z$
1440 NEXT J
1450 PRINT @41:'                                   (H) ';
1460 IF I=K1*M+1 THEN 1500
1470 FOR H=1 TO I-K1*M-1
1480 PRINT @41:'     ! ';
1490 NEXT H
1500 PRINT @41:Z$
1510 IF I=K1*M+1 THEN 1560
1520 PRINT @41:'                                   (H) ';
1530 FOR H=1 TO I-K1*M-1
1540 PRINT @41:'     ! ';
1550 NEXT H
1560 PRINT @41:
1570 NEXT I
1580 RETURN
```

To Operate Key 6-B

```
100 INIT
110 PRINT 'LJJ     NBS PAPER PHYSICS DATA FILE  -  INFO. TYPES I, IV'
120 PRINT '_____        PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '            [RETURN] TO CONTINUEGG...........................';
140 INPUT Z$
150 FIND 1
160 IF TYP(0)=3 THEN 180
170 GO TO 120
180 READ @33:N,A$,B$,C$,D$,E$,Z$
190 PRINT @41:'L     NBS PAPER PHYSICS DATA FILE  - INFO. TYPES I, IV'
200 PRINT @41:
210 PRINT @41:
220 PRINT @41:
```

Appendix VI - continued

```
230 PRINT @41:"1. NBS REPORT NUMBER:              ";N
240 PRINT @41:
250 PRINT @41:"2. NBS REPORT TITLE:               ";A$
260 PRINT @41:"                                   ";B$
270 PRINT @41:"                                   ";C$
280 PRINT @41:
290 PRINT @41:"3. AUTHOR(S):                      ";D$
300 PRINT @41:"                                   ";E$
310 PRINT @41:
320 PRINT @41:"4. KEYWORDS:                       ";Z$
330 IF TYP(0)=1 THEN 370
340 READ @33:Z$
350 PRINT @41:"                                   ";Z$
360 GO TO 330
370 PRINT @41:
380 PRINT @41:
390 PRINT @41:
400 FIND 2
410 READ @33:N1,Z$
420 C2=1
430 IF TYP(0)=1 THEN 470
440 READ @33:Z$
450 C2=C2+1
460 GO TO 430
470 FIND 3
480 READ @33:M,Z$
490 C1=1
500 READ @33:Z$
510 IF Z$="END" THEN 540
520 C1=C1+1
530 GO TO 500
540 DIM D(C2,C1)
550 FIND 5
560 READ @33:D
570 PRINT @41:"         NBS PAPER PHYSICS DATA FILE  -  DATA MATRIX FOR ";
580 PRINT @41:"REPORT # ";N
590 PRINT @41:
600 PRINT @41:
610 K=INT(C1/(M+1))
620 K1=0
630 PRINT @41:"                                (U)  SAMPLE LABEL #"
640 GOSUB 1340
650 PRINT @41:
660 GOSUB 880
670 FIND 2
680 READ @33:N1
690 FOR J=1 TO C2
700 READ @33:Z$
710 PRINT @41:"  P:";
720 PRINT @41: USING 1370:J
730 GOSUB 950
740 NEXT J
750 GOSUB 880
760 GOSUB 1340
770 PRINT @41:
780 GOSUB 1430
790 FOR L=1 TO 4
800 PRINT @41:
810 NEXT L
820 IF K1=K THEN 850
830 K1=K1+1
840 GO TO 630
850 PRI "_____       MARK THOSE BOXES WHICH CORRESPOND TO DATA VALUES,"
860 PRI "        RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).";
870 END
```

Appendix VI - continued

```
880 PRINT @41:'==============================(B)B======';
890 FOR I=K1*M+1 TO (K1+1)*M
900 PRINT @41:'=B!=====';
910 IF I=C1-1 OR I=(K1+1)*M-1 THEN 930
920 NEXT I
930 PRINT @41:'=B!'
940 RETURN
950 PRINT @41:') ';Z$;
960 FOR S=1 TO 21-LEN(Z$)
970 PRINT @41:' ';
980 NEXT S
990 PRINT @41:'(B)';
1000 FIND 5
1010 IF J=1 AND K1=0 THEN 1050
1020 FOR I=1 TO K1*C2*M+(J-1)*M
1030 READ @33:B
1040 NEXT I
1050 FOR I=1 TO M
1060 READ @33:C
1070 IF C=0 THEN 1100
1080 C$=STR(C)
1090 GO TO 1110
1100 C$=' '
1110 FOR S=1 TO INT((5-LEN(C$))/2)
1120 PRINT @41:' ';
1130 NEXT S
1140 PRINT @41:C$;
1150 FOR S=1 TO INT((6-LEN(C$))/2)
1160 PRINT @41:' ';
1170 NEXT S
1180 PRINT @41:'!';
1190 NEXT I
1200 PRINT @41:
1210 IF J=C2 THEN 1330
1220 PRINT @41:'---- -------------------------(B)B------';
1230 FOR I=K1*M+1 TO (K1+1)*M
1240 PRINT @41:'-B!-----';
1250 IF I=C1-1 OR I=(K1+1)*M-1 THEN 1270
1260 NEXT I
1270 PRINT @41:'-B!'
1280 FIND 2
1290 READ @33:N1
1300 FOR J1=1 TO J
1310 READ @33:Z$
1320 NEXT J1
1330 RETURN
1340 PRINT @41:'    PRIMARY TEST VARIABLE    (B) S:';
1350 FOR I=K1*M+1 TO (K1+1)*M
1360 PRINT @41: USING 1370:I
1370 IMAGE 2D,S
1380 IF I=C1 OR I=(K1+1)*M THEN 1410
1390 PRINT @41:'! S:';
1400 NEXT I
1410 PRINT @41:'!';
1420 RETURN
1430 IF K1=K THEN 1460
1440 FOR I=(K1+1)*M TO K1*M+1 STEP -1
1450 GO TO 1470
1460 FOR I=C1 TO K1*M+1 STEP -1
1470 FIND 3
1480 READ @33:M
1490 FOR J=1 TO I
1500 READ @33:Z$
1510 NEXT J
```

Appendix VI - continued

```
1520 PRINT @41:"                                          (B) ";
1530 IF I=K1*M+1 THEN 1570
1540 FOR H=1 TO I-K1*M-1
1550 PRINT @41:"     ! ";
1560 NEXT H
1570 PRINT @41:Z$
1580 IF I=K1*M+1 THEN 1630
1590 PRINT @41:"                                          (B) ";
1600 FOR H=1 TO I-K1*M-1
1610 PRINT @41:"     ! ";
1620 NEXT H
1630 PRINT @41:
1640 NEXT I
1650 RETURN
```

To Operate Key 7

```
100 INIT
110 PRINT "LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE V"
120 PRINT "__        PLEASE INSERT THE DATA TAPE FOR DATA STORAGE,"
130 PRINT "           [RETURN] TO CONTINUEGG........................";
140 INPUT A$
150 PRINT "__        KILL EXISTING FILES?  [Y OR N]:   ";
160 INPUT A$
170 IF A$="N" THEN 230
180 FIND 6
190 IF TYP(0)=2 THEN 120
200 MARK 1,2500
210 FIND 7
220 MARK 3,7500
230 K1=0
240 P=0
250 S=0
260 FIND 2
270 READ @33:N
280 READ @33:Z$
290 P=P+1
300 IF TYP(0)<>1 THEN 280
310 FIND 3
320 READ @33:M
330 READ @33:Z$
340 S=S+1
350 IF Z$<>"END" THEN 330
360 S=S-1
370 PRINT "L__1. NBS REPORT NUMBER:G       ";N
380 PRINT "_2. TEST VARIABLE UNITS:G  TYPE APPROPRIATE UNIT._"
390 FIND 6
400 FOR I=1 TO P
410 PRINT "    P:";
420 PRINT USING 430:I
430 IMAGE 2D,S
440 PRINT ")G    ";
450 INPUT V$
460 WRITE V$
470 NEXT I
480 GOSUB 1020
490 DIM D(P,M),B(P,M)
500 FIND 5
510 IF K1=0 THEN 550
520 FOR I=1 TO K1
530 READ @33:B
540 NEXT I
550 READ @33:D
```

Appendix VI - continued

```
560 FIND 7
570 GOSUB 1060
580 FOR I=1 TO M
590 PRINT '   S:';
600 PRINT USING 430:K1*M+I
610 PRINT ')';
620 FOR J=1 TO P
630 GO TO SGN(D(J,I)-1)+2 OF 640,670,730
640 L=-1.0E+300
650 WRITE L
660 GO TO 930
670 PRINT 'IP:';
680 PRINT USING 430:J
690 PRINT ')     ';
700 INPUT L
710 WRITE L
720 GO TO 930
730 L=D(J,I)*1.0E+300
740 WRITE L
750 DELETE K
760 DIM K(D(J,I)),R(D(J,I))
770 FOR H=1 TO D(J,I)
780 PRINT 'IP:';
790 PRINT USING 430:J
800 PRINT '-';H;')  ';
810 INPUT K(H)
820 PRINT 'KIISECONDARY VALUE:  ';
830 INPUT R(H)
840 NEXT H
850 FIND 8
860 GOSUB 1060
870 WRITE K
880 FIND 9
890 GOSUB 1060
900 WRITE R
910 FIND 7
920 GOSUB 1060
930 NEXT J
940 GOSUB 1020
950 NEXT I
960 IF K1=INT(S/(M+1)) THEN 990
970 K1=K1+1
980 GO TO 490
990 PRINT '____            ** DATA STORED **GGG_            ';
1000 PRINT 'RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).';
1010 END
1020 PRINT 'L__1. NBS REPORT NUMBER:G       ';N
1030 PRINT
1040 PRINT '3. TEST DATA:G  TYPE DATA VALUE TO BE STORED__'
1050 RETURN
1060 IF TYP(0)=0 OR TYP(0)=1 THEN 1090
1070 READ @33:Z9
1080 GO TO 1060
1090 RETURN
```

To Operate Key 8

```
100 INIT
110 PRINT 'LJJ      NBS PAPER PHYSICS DATA FILE  -  INFORMATION TYPE V'
120 PRINT '__        PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,'
130 PRINT '           [RETURN] TO CONTINUEGG.........................';
140 INPUT A$
150 P=0
160 S=0
170 H=1
180 H1=1
190 FIND 2
200 READ @33:N
210 READ @33:Z$
220 P=P+1
230 IF TYP(0)<>1 THEN 210
240 FIND 3
250 READ @33:M
260 READ @33:Z$
270 S=S+1
```

Appendix VI - continued

```
280 IF Z$<>"END" THEN 260
290 S=S-1
300 DIM K(1000)
310 FIND 8
320 IF TYP(0)=0 OR TYP(0)=1 THEN 360
330 READ @33:K(H)
340 H=H+1
350 GO TO 320
360 PRINT "L__1. NBS REPORT NUMBER:G       ";N
370 PRINT "__    DO YOU WISH TO SEE TEST DATA FOR:  (1) A PRIMARY ";
380 PRINT "VARIABLE , OR_II  (2) A TEST SAMPLE  :  ";
390 INPUT A
400 GO TO A OF 1040,410
410 PRINT "_    ENTER SAMPLE CODE NUMBER  (1 TO ";S;"):  ";
420 INPUT B
430 FIND 3
440 READ @33:M
450 FOR I=1 TO B
460 READ @33:S$
470 NEXT I
480 PRINT "__    SAMPLE CHOSEN:  ";S$;"GG"
490 GOSUB 1950
500 PRINT @41:"SAMPLE:  ";S$
510 PRINT @41:
520 PRINT @41:"TEST VARIABLE                ;  TEST DATA   (UNITS)"
530 PRINT @41:"-------------------------H;------------------------------"
540 DIM D(S,P)
550 FIND 7
560 READ @33:D
570 IF B=1 THEN 640
580 FOR I0=1 TO B-1
590 FOR J0=1 TO P
600 IF D(I0,J0)<1.0E+300 THEN 620
610 H1=H1+D(I0,J0)/1.0E+300
620 NEXT J0
630 NEXT I0
640 FOR I=1 TO P
650 IF D(B,I)=-1.0E+300 THEN 1020
660 D$=STR(D(B,I))
670 FIND 2
680 READ @33:N
690 FOR J=1 TO I
700 READ @33:P$
710 NEXT J
720 FIND 6
730 FOR J=1 TO I
740 READ @33:U$
750 NEXT J
760 IF D(B,I)>1.0E+300 THEN 870
770 PRINT @41:P$;
780 FOR S9=1 TO 25-LEN(P$)
790 PRINT @41:" ";
800 NEXT S9
810 PRINT @41:";  ";D$;
820 FOR S9=1 TO 12-LEN(D$)
830 PRINT @41:" ";
840 NEXT S9
850 PRINT @41:"(";U$;")"
860 GO TO 1020
870 PRINT @41:"                          ;"
880 FOR J=H1 TO H1+D(B,I)/1.0E+300-1
890 D$=STR(K(J))
900 PRINT @41:P$;" (";J-H1+1;")";
910 FOR S9=1 TO 21-LEN(P$)
920 PRINT @41:" ";
930 NEXT S9
940 PRINT @41:";  ";D$;
950 FOR S9=1 TO 12-LEN(D$)
960 PRINT @41:" ";
970 NEXT S9
```

Appendix VI - continued

```
980 PRINT @41:"(";U$;")"
990 NEXT J
1000 H1=H1+D(B,I)/1.0E+300
1010 PRINT @41:"                                  :"
1020 NEXT I
1030 GO TO 1890
1040 PRINT "_    ENTER VARIABLE CODE NUMBER  (1 TO ";P;"):  ";
1050 INPUT B
1060 FIND 2
1070 READ @33:N
1080 FOR I=1 TO B
1090 READ @33:P$
1100 NEXT I
1110 PRINT "   VARIABLE CHOSEN:  ";P$;"GG"
1120 PRI "_   ENTER SECONDARY VARIABLE CODE LETTER (RETURN IF NONE):  ";
1130 INPUT A$
1140 IF A$="" THEN 1250
1150 FIND 3
1160 READ @33:M
1170 FOR I=1 TO S+ASC(A$)-63
1180 READ @33:V$
1190 NEXT I
1200 PRINT "   VARIABLE CHOSEN:  ";V$;"GG"
1210 PRINT "__   SELECT:    (1) TABLE WITH SECONDARY VARIABLES"
1220 PRINT "IHHHH(2) TABLE WITHOUT SECONDARY VARIABLES          -->  ";
1230 INPUT T1
1240 GO TO 1260
1250 T1=2
1260 FIND 6
1270 FOR J=1 TO B
1280 READ @33:U$
1290 NEXT J
1300 GOSUB 1950
1310 PRINT @41:"VARIABLE:  ";P$;"  (";U$;")"
1320 IF T1=2 THEN 1340
1330 PRINT @41:"SECONDARY VARIABLE:  ";V$
1340 PRINT @41:
1350 PRINT @41:"TEST SAMPLE  (SEC. VAR. VALUE) :  TEST DATA   (";U$;")"
1360 PRINT @41:"--------------------------------H!--------------------";
1370 PRINT @41:"--------------------"
1380 DIM D(S,P)
1390 FIND 7
1400 READ @33:D
1410 FOR I=1 TO S
1420 IF D(I,B)=-1.0E+300 THEN 1880
1430 D$=STR(D(I,B))
1440 FIND 3
1450 READ @33:M
1460 FOR J=1 TO I
1470 READ @33:S$
1480 NEXT J
1490 IF D(I,B)>1.0E+300 THEN 1560
1500 PRINT @41:S$;
1510 FOR S9=1 TO 31-LEN(S$)
1520 PRINT @41:" ";
1530 NEXT S9
1540 PRINT @41:":  ";D$
1550 GO TO 1880
1560 IF T1=2 THEN 1880
1570 H0=1
1580 DIM R(1000)
1590 FIND 9
1600 IF TYP(0)=0 OR TYP(0)=1 THEN 1640
1610 READ @33:R(H0)
1620 H0=H0+1
1630 GO TO 1600
1640 IF I=1 THEN 1710
1650 FOR I0=1 TO I-1
1660 FOR J0=1 TO P
1670 IF D(I0,J0)<1.0E+300 THEN 1690
```

Appendix VI - continued

```
1680 H1=H1+D(I0,J0)/1.0E+300
1690 NEXT J0
1700 NEXT I0
1710 IF B=1 THEN 1760
1720 FOR J=1 TO B-1
1730 IF D(I,J)<1.0E+300 THEN 1750
1740 H1=H1+D(I,J)/1.0E+300
1750 NEXT J
1760 PRINT @41:"                                    :"
1770 FOR J=H1 TO H1+D(I,B)/1.0E+300-1
1780 D$=STR(K(J))
1790 R$=STR(R(J))
1800 PRINT @41:S$;" (";R(J);")";
1810 FOR S9=1 TO 29-LEN(S$)-LEN(R$)
1820 PRINT @41:" ";
1830 NEXT S9
1840 PRINT @41:":  ";D$
1850 NEXT J
1860 H1=1
1870 PRINT @41:"                                    :"
1880 NEXT I
1890 PRINT "__       REPEAT?  (Y OR N):  ";
1900 INPUT R$
1910 IF R$="Y" THEN 360
1920 PRINT "____       *** DATA RETRIEVED ***GGG"
1930 PRI "         RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD).";
1940 END
1950 PRINT @41:"L  NBS PAPER PHYSICS DATA FILE  -";
1960 PRINT @41:"  DATA TABLE FOR REPORT # ";N
1970 PRINT @41:
1980 PRINT @41:
1990 RETURN
```

To operate Key 9

```
100 INIT
110 PRINT "LJJ       NBS PAPER PHYSICS DATA FILE  -  TEST DATA PLOT"
120 PRINT "__         PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,"
130 PRINT "             [RETURN] TO CONTINUEGG........................";
140 INPUT A$
150 P=0
160 S=0
170 FIND 2
180 READ @33:N
190 READ @33:Z$
200 P=P+1
210 IF TYP(0)<>1 THEN 190
220 FIND 3
230 READ @33:M
240 READ @33:Z$
250 S=S+1
260 IF Z$<>"END" THEN 240
270 S=S-1
280 PRINT "L__     NBS REPORT NUMBER:      ";N
290 PRINT "__     SELECT:       (1) ENTER PLOT VARIABLE"
300 PRINT "I(2) ENTER PLOT PARAMETERS_I(3) **PLOT ON SCREEN**"
310 PRINT "I(4) **PLOT ON PLOTTER**_I(5)   ENDGGI          -->  ";
320 INPUT A
330 GO TO A OF 350,580,660,680,1280
340 GO TO 290
350 PRINT "____ENTER THE PRIMARY TEST VARIABLE CODE NUMBER:   ";
360 INPUT B
370 ON EOF (0) THEN 350
380 FIND 2
390 READ @33:N
400 FOR I=1 TO B
410 READ @33:P$
420 NEXT I
430 PRINT "__VARIABLE CHOSEN:  ";P$;"GG"
440 FIND 6
450 FOR J=1 TO B
460 READ @33:U$
470 NEXT J
480 DIM C(S,P),D(S)
490 H=0
500 FIND 7
510 READ @33:C
```

```
520 FOR I=1 TO S
530 D(I)=C(I,B)
540 IF D(I)=-1.0E+300 OR D(I)>1.0E+300 THEN 560
550 H=H+1
560 NEXT I
570 GO TO 280
580 PRINT "____ENTER THE PLOT PARAMETERS:G"
590 PRINT "    TEST VARIABLE (Y-AXIS) MINIMUM:  ";
600 INPUT Y1
610 PRINT "    TEST VARIABLE (Y-AXIS) MAXIMUM:  ";
620 INPUT Y2
630 PRINT "    TEST VARIABLE (Y-AXIS) TIC-MARK INTERVAL:  ";
640 INPUT Y3
650 GO TO 280
660 Z1=32
670 GO TO 690
680 Z1=1
690 PAGE @Z1:
700 WINDOW 0,1.5*H+0.5,Y1,Y2
710 VIEWPORT 12,125,20,85
720 PRINT @Z1:
730 PRINT @Z1:
740 FOR S9=1 TO (55-LEN(P$))/2
750 PRINT @Z1:" ";
760 NEXT S9
770 PRINT @Z1:P$;" vs. TEST SAMPLES"
780 N$=STR(N)
790 FOR S9=1 TO (72-LEN(N$))/2
800 PRINT @Z1:" ";
810 NEXT S9
820 PRINT @Z1:N
830 AXIS @Z1:0,Y3
840 IF Z1=32 THEN 930
850 HOME @1:
860 FOR S9=1 TO LEN(P$)+(27-LEN(P$))/2
870 PRINT @1:"J";
880 NEXT S9
890 PRINT @1:" ";
900 PRINT @1,25:90
910 PRINT @1:P$
920 PRINT @1,25:0
930 FOR I=Y1 TO Y2 STEP Y3
940 MOVE @Z1:0,I
950 PRINT @Z1:"HHHH";I
960 NEXT I
970 MOVE @Z1:0,Y2
980 PRINT @Z1:"  (";U$;")"
990 H1=0
1000 FOR J=1 TO S
1010 IF D(J)=-1.0E+300 OR D(J)>1.0E+300 THEN 1230
1020 MOVE @Z1:1.5*H1+0.5,0
1030 RDRAW @Z1:0,D(J)
1040 RDRAW @Z1:1,0
1050 RDRAW @Z1:0,-D(J)
1060 H1=H1+1
1070 FIND 3
1080 READ @33:M
1090 FOR I=1 TO J
1100 READ @33:S$
1110 NEXT I
1120 IF Z1=1 THEN 1170
1130 IF H1/2<>INT(H1/2) THEN 1150
1140 PRINT @Z1:"J";
1150 PRINT @Z1:"JHHH";S$
1160 GO TO 1230
1170 SET DEGREES
1180 PRINT @Z1,25:30
1190 FOR S9=1 TO LEN(S$)+2
1200 PRINT @Z1:"H";
1210 NEXT S9
1220 PRINT @Z1:S$
1230 NEXT J
1240 PRINT @Z1,25:0
1250 IF Z1=1 THEN 280
1260 INPUT A$
1270 GO TO 280
1280 PRINT "____GG";
1290 PRI "           RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD)";
1300 END
```

Appendix VI - continued

To operate Kev 10

```
100 INIT
110 PRINT "LJJ        NBS PAPER PHYSICS DATA FILE   -   TEST DATA PLOT"
120 PRINT "__          PLEASE INSERT THE DATA TAPE FOR DATA RETRIEVAL,"
130 PRINT "             [RETURN] TO CONTINUEGG.........................";
140 INPUT A$
150 P=0
160 S=0
170 FIND 2
180 READ @33:N
190 READ @33:Z$
200 P=P+1
210 IF TYP(0)<>1 THEN 190
220 FIND 3
230 READ @33:M
240 READ @33:Z$
250 S=S+1
260 IF Z$<>"END" THEN 240
270 S=S-1
280 PRINT "L__      NBS REPORT NUMBER:       ";N
290 PRINT "__      SELECT:       (1) ENTER PLOT VARIABLES"
300 PRINT "I(2) ENTER PLOT PARAMETERS_I(3) **PLOT ON SCREEN**"
310 PRINT "I(4) **PLOT ON PLOTTER**_I(5)   ENDGGI            -->  ";
320 INPUT A
330 GO TO A OF 350,1010,1200,1220,2010
340 GO TO 290
350 PRINT "____ENTER THE PRIMARY TEST VARIABLE CODE NUMBER:    ";
360 INPUT B
370 FIND 2
380 READ @33:N
390 FOR I=1 TO B
400 READ @33:P$
410 NEXT I
420 PRINT "VARIABLE CHOSEN:  ";P$;"GG"
430 PRINT "_ENTER THE TEST SAMPLE CODE NUMBER:    ";
440 INPUT B1
450 FIND 3
460 READ @33:M
470 FOR I=1 TO B1
480 READ @33:S$
490 NEXT I
500 PRINT "SAMPLE CHOSEN:  ";S$;"GG"
510 PRINT "_ENTER THE SECONDARY TEST VARIABLE CODE LETTER:    ";
520 INPUT B$
530 READ @33:Z$
540 IF Z$<>"END" THEN 530
550 FOR I=1 TO ASC(B$)-64
560 READ @33:V$
570 NEXT I
580 P9=POS(V$," (",1)
590 IF P9<>0 THEN 620
600 W$=V$
610 GO TO 630
620 W$=SEG(V$,1,P9-1)
630 PRINT "VARIABLE CHOSEN:  ";W$;"GG"
640 H=1
650 H1=1
660 DIM C(S,P),D(1000),R(1000)
670 FIND 7
680 READ @33:C
690 FIND 8
```

Appendix VI - continued

```
700 IF TYP(0)=0 THEN 350
710 IF TYP(0)=1 THEN 750
720 READ @33:D(H)
730 H=H+1
740 GO TO 710
750 FIND 9
760 ON EOF (0) THEN 780
770 READ @33:R
780 IF C(B1,B)<1.0E+300 THEN 350
790 C1=C(B1,B)/1.0E+300
800 DIM V(C1),W(C1)
810 IF B1=1 THEN 920
820 FOR I0=1 TO B1-1
830 FOR J0=1 TO P
840 IF C(I0,J0)<1.0E+300 THEN 860
850 H1=H1+C(I0,J0)/1.0E+300
860 NEXT J0
870 NEXT I0
880 FOR J=1 TO B-1
890 IF C(B1,J)<1.0E+300 THEN 910
900 H1=H1+C(B1,J)/1.0E+300
910 NEXT J
920 FOR J=H1 TO H1+C1-1
930 W(J-H1+1)=D(J)
940 V(J-H1+1)=R(J)
950 NEXT J
960 FIND 6
970 FOR J=1 TO B
980 READ @33:U$
990 NEXT J
1000 GO TO 280
1010 PRINT "____ENTER THE PLOT PARAMETERS:G"
1020 PRINT "   PRIMARY VARIABLE (Y-AXIS) MINIMUM:   ";
1030 INPUT Y1
1040 PRINT "   PRIMARY VARIABLE (Y-AXIS) MAXIMUM:   ";
1050 INPUT Y2
1060 PRINT "   PRIMARY VARIABLE (Y-AXIS) TIC-MARK INTERVAL:   ";
1070 INPUT Y3
1080 PRINT "_   SECONDARY VARIABLE (X-AXIS) MINIMUM:   ";
1090 INPUT X1
1100 PRINT "   SECONDARY VARIABLE (X-AXIS) MAXIMUM:   ";
1110 INPUT X2
1120 PRINT "   SECONDARY VARIABLE (X-AXIS) TIC-MARK INTERVAL:   ";
1130 INPUT X3
1140 PRINT "_   SELECT:        (1) LINE PLOT MODE"
1150 PRINT "                  (2) DOT PLOT MODE"
1160 PRINT "                  (3) DASH PLOT MODE"
1170 PRINT "                  (4) POINT-ONLY PLOT MODE    -->   ";
1180 INPUT M1
1190 GO TO 280
1200 Z1=32
1210 GO TO 1230
1220 Z1=1
1230 PAGE @Z1:
1240 WINDOW X1,X2,Y1,Y2
1250 VIEWPORT 14,105,15,82
1260 PRINT @Z1:
1270 PRINT @Z1:
1280 FOR S9=1 TO (67-LEN(P$)-LEN(W$))/2
1290 PRINT @Z1:" ";
1300 NEXT S9
1310 PRINT @Z1:P$;" vs. ";W$
1320 N$=STR(N)
1330 FOR S9=1 TO (72-LEN(N$))/2
1340 PRINT @Z1:" ";
1350 NEXT S9
```

Appendix VI - continued

```
1360 PRINT @Z1:N
1370 AXIS @Z1:X3,Y3
1380 PRINT @Z1:
1390 PRINT @Z1:
1400 PRINT @Z1:
1410 FOR S9=1 TO (72-LEN(V$))/2
1420 PRINT @Z1:" ";
1430 NEXT S9
1440 PRINT @Z1:V$
1450 FOR I=X1 TO X2 STEP X3
1460 MOVE @Z1:I,Y1
1470 PRINT @Z1:"JH";I
1480 NEXT I
1490 IF Z1=32 THEN 1580
1500 HOME @1:
1510 FOR S9=1 TO LEN(P$)+(27-LEN(P$))/2
1520 PRINT @1:"J";
1530 NEXT S9
1540 PRINT @1:" ";
1550 PRINT @1,25:90
1560 PRINT @1:P$
1570 PRINT @1,25:0
1580 FOR I=Y1 TO Y2 STEP Y3
1590 MOVE @Z1:X1,I
1600 PRINT @Z1:"HHHH";I
1610 NEXT I
1620 MOVE @Z1:X1,Y2
1630 PRINT @Z1:"  (";U$;")"
1640 MOVE @Z1:V(1),W(1)
1650 FOR J=2 TO C1+1
1660 SCALE 1,1
1670 RDRAW @Z1:0,0
1680 RMOVE @Z1:0,1
1690 RDRAW @Z1:1,-1
1700 RDRAW @Z1:-1,-1
1710 RDRAW @Z1:-1,1
1720 RDRAW @Z1:1,1
1730 RMOVE @Z1:0,-1
1740 WINDOW X1,X2,Y1,Y2
1750 IF J=C1+1 THEN 1970
1760 GO TO M1 OF 1790,1810,1880
1770 MOVE @Z1:V(J),W(J)
1780 GO TO 1960
1790 DRAW @Z1:V(J),W(J)
1800 GO TO 1960
1810 FOR J1=1 TO 10
1820 X9=V(J-1)+J1*(V(J)-V(J-1))/10
1830 Y9=W(J-1)+J1*(W(J)-W(J-1))/10
1840 MOVE @Z1:X9,Y9
1850 RDRAW @Z1:0,0
1860 NEXT J1
1870 GO TO 1960
1880 FOR J1=1 TO 3
1890 X9=V(J-1)+(2*J1-1)*(V(J)-V(J-1))/6
1900 Y9=W(J-1)+(2*J1-1)*(W(J)-W(J-1))/6
1910 MOVE @Z1:X9,Y9
1920 X9=X9+(V(J)-V(J-1))/6
1930 Y9=Y9+(W(J)-W(J-1))/6
1940 DRAW @Z1:X9,Y9
1950 NEXT J1
1960 NEXT J
1970 PRINT @Z1:"  ";S$
1980 IF Z1=1 THEN 280
1990 INPUT A$
2000 GO TO 280
2010 PRINT "____GG";
2020 PRI "  -  -    RETURN TO MENU VIA OPERATING SYSTEM (USE AUTO-LOAD)";
2030 END
```

NOTES

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

As a necessary step towards the modeling of the microstructural changes of paper due to environmental and mechanical loadings, a computer-aided data file for a collection of 47 NBS reports (1953-1976) is created. Using an in-house experimental database management system (COLLIN) as implemented on an NBS computer (DEC PDP-10), a mini-data bank for the 47 technical reports is set up with the following searchable parameters: (a) report number, (b) author's name, (c) keyword, (d) test sample label, and (e) primary test variable. Each search will yield a complete record containing all the searchable information as well as (f) title of report, (g) citation, (h) the abstract, and (i) the so-called secondary test variable. To obtain quantitative information from any specific report for some combinations of sample labels and test variables for which experimental data were reported, a data tape is prepared and implemented for retrieval on a leased mini-computer graphical system (Tektronix 4051 with printer 4641 and plotter 4662). The operating system using the computer language BASIC is general enough to assist any scientist or engineer to create a personal data file at a reasonable cost. It is clearly demonstrated that no prior training in the use of a computer is necessary for the implementation of this project.

During this reporting period, experiments on relating the quantity of water in the cellulose walls of pulp fibers to the cross-sectional morphology of fibers in paper were in progress. A brief discussion of this aspect of work is included in this report.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Computer graphics; data base management; data retrieval; durability; fatigue; interactive system; mathematical modeling; paper; paper fiber; report retrieval; scientific data.

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